ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

Founded 1920

For Victory Through Armament Production

Volume XXII | JANUARY-FEBRUARY, 1942 | No. 130

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Published by the Army Ordnance Association, Suite 705, Mills Building, Washington, D. C. Editor: Lieut. Col. L. A. Codd, Ord. Res.; Associate Editor: R. E. Lewis, Jr. Authors are responsible for statements and opinions expressed in their articles. Copyright, 1941, by the Army Ordnance Association, Washington, D. C. Permission for republication in whole or in part must be obtained in advance.

Issued bimonthly. Single copy 75c (by mail). Subscription rate: continental U. S., $4.50 annually; foreign, $6.00, in advance. Entered as second-class matter, August 14, 1920, at the Post Office at Washington, D. C., under the Act of March 3, 1879. Additional second-class entry at the Post Office at Richmond, Va. Three weeks' notice before publication date of next issue required for change of address.

THE ARMY ORDNANCE ASSOCIATION

The Aims, Purposes, and National Officers of the Society

THE Army Ordnance Association, a national society of more than 10,000 American citizens, was founded in 1919, "pledged to industrial preparedness for war as our nation's strongest guaranty of peace." The society was incorporated under the laws of the District of Columbia in 1928. Its entire energies are now dedicated to victory for the armed forces of the United States. For the duration of the war it is "pledged to victory—complete, absolute, final."

The Association has endeavored during the past twenty-two years to keep alive an interest in and knowledge of the design, production, and maintenance of military armament. This it has done through periods of public lassitude and times of great national emergency. Until 1940 there was no peace-time armament industry in the United States for the production of ordnance. Now all American industry is being geared rapidly for victorious war production.

The principal objective of the society is an active membership of American citizens to assist in the design, development, procurement, production, maintenance, and supply functions of the Ordnance Department of the United States Army. When peace returns this body of informed citizens will again continue to be a bulwark of knowledge, experience, and ability upon whom the Armed Forces of the United States can rely for technical and scientific assistance and for industrial preparedness.

The Association is devoted solely to the national defense; it has no commercial interests, no political alliances, and no religious affiliations. It is not operated for profit: its income is expended in furthering its aims. Its elected officers and directors serve without remuneration. Membership, to which American male citizens are eligible, is four dollars a year. (Application on request.) There are eighteen local chapters of the Association throughout the United States.

ARMY ORDNANCE, the journal of the Association, is published solely for the purpose of disseminating information on the progress of our munitions developments so that American industry may at all times know its responsibilities to the common defense.

The objectives of the Association as set forth in its Constitution are:

To assist in effecting industrial preparedness for war as being one of the nation's strongest guaranties of peace;

To keep available the highly specialized knowledge necessary for arming the manhood of the nation by stimulating interest in the design and production of ordnance material;

To promote mutual understanding and to effect coöperation with American scientists, inventors, engineers and manufacturers in civil life and the Regular and Reserve officers of the Ordnance Department;

To provide, when required, the services of competent committees to investigate and report upon special ordnance subjects;

To assist in developing and maintaining an efficient personnel, both commissioned and enlisted, for the units required for Ordnance Field Service in the event of an emergency;

To commemorate the services rendered by the industry of the nation and by the officers and civilian employees of the Ordnance Department in the wars in which the United States has been engaged.

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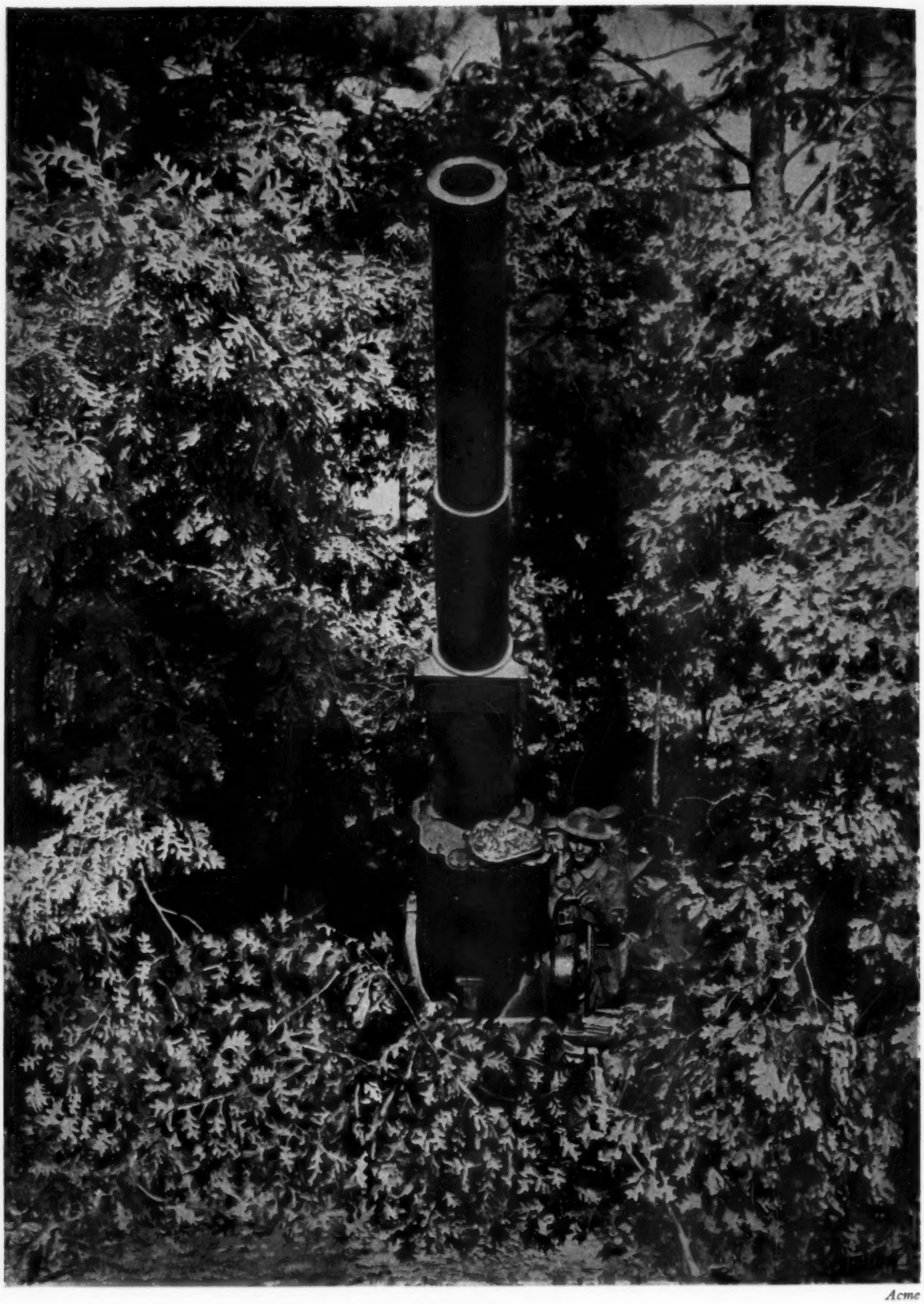

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Sentinel

ARMY ORDNANCE

Volume XXII JANUARY-FEBRUARY, 1942 No. 130

Ordnance

A Record of the Army's Development and Production of Weapons

Maj. Gen. C. M. Wesson*

I AM grateful for the opportunity to be present at the founding of the eighteenth local chapter of the Army Ordnance Association and at the presentation of the Rice Medal to John C. Garand. Being a charter member of the Army Ordnance Association, I have always been most interested in its activities and growth, and it is gratifying that a new chapter of the society has been formed here in this important industrial area.

Brig. Gen. John H. Rice, for whom the new medal is named, was a great engineer. I served under him more than once and he was my good friend. Thus, I am particularly happy to be present when a medal which bears his name is awarded for the first time. No recipient of the medal is more entitled to have it than the man to whom it was presented tonight. From the very beginning of the development of the Garand rifle, I had the utmost confidence in the ability of Mr. Garand as an engineer. When not every one felt that the Garand rifle was all that we of the Ordnance Department claimed for it, we stood our ground, I think with befitting insistence. Now that the Garand rifle is acclaimed everywhere as a foremost weapon for the defense of the American soldier, the faith of the Ordnance Department again is asserted in the Garand, and it acclaims, with the Army Ordnance Association, the man who started that great development and who carried it through to such successful conclusion. Mr. Garand, I add my congratulations to those of all here present. You deserve the Rice Medal in abundant measure!

Gentlemen, mention of the Garand rifle and all its trials and tribulations which were so completely surmounted, puts me in the frame of mind to speak to you very candidly tonight about certain other Ordnance developments. Judging by what I read from time to time in some of our magazines and occasionally in the daily press, some of these subjects are not always understood. It seems to me that this occasion is appropriate for a restatement of what is being done in the development and production of certain very important types of ordnance. I refer first to tanks; secondly, to artillery; thirdly, to antitank artillery; fourthly, to self-propelled gun mounts; fifthly, to antiaircraft artillery, and, sixthly, to infantry helmets. Let us begin with tanks.

IN close coöperation with our great automotive industry, the Ordnance Department of the Army has continuously studied and developed tanks since the close of the World War. Within the limits of small congressional appropriations, experimental models were continuously built and tested at Aberdeen Proving Ground and under field conditions with troops.

During this period, the Ordnance Department carefully considered, studied, and tested many radical tank designs. Some of these designs had outstanding features which appeared very desirable to the layman but were not practical because many other military requirements necessarily would have to be built into such tanks to insure effective operation.

When funds were made available by the first large congressional appropriations of September 1940, the Ordnance Department was prepared with designs of tanks which could be put immediately into manufacture. The first tank model to get into quantity production was the light tank, of which the principal manufacturer is the American Car and Foundry Company. Production of these tanks already has been adequate to meet the light-tank requirements of the armored divisions now organized in the United States Army and to ship considerable numbers of light tanks to the British. The British have pronounced these American light tanks the best on either side. American observers in Libya have corroborated this opinion.

As lessons have been learned from the operation of these tanks abroad and in maneuvers conducted by our own Army, improvements have been introduced. Our present light tank now is considered the equal in battle effectiveness to what in Europe are called medium tanks.

Orders for our medium tanks were placed the moment funds were available. The locomotive industry in general was called on to manufacture this tank, since the problems of construction of a locomotive are nearer than any other commercial item to those of a tank. These companies promptly began retooling their plants and, at the same time, the Ordnance Department initiated a project with the Chrysler Corporation to construct a plan specifically designed for the manufacture of tanks. In less than one year, what formerly had been a cornfield was turning out 30-ton medium tanks. Five other American companies are now in production of the medium tank and two great automobile companies, Ford and General Motors, will shortly begin work to meet the new demands for medium tanks. This medium tank is considered the equivalent in battle effectiveness of the so-called heavy tanks of Europe.

According to reports of impartial British and American observers, the American light and medium tanks are considered vastly superior to European models. They not only have greater fire power, maneuverability, and speed, but many times the powers of endurance. And, finally, our tanks have a device which greatly increases the number of hits by projectiles fired from them when operating at high speed over difficult terrain.

*Chief of Ordnance, U. S. Army.
This is an address delivered at the inaugural meeting of the Hartford-Springfield Post, Army Ordnance Association, November 18, 1941, the Hotel Bond, Hartford, Conn.

From the production standpoint, the tank-manufacturing program has suffered from priorities lower than those of ships and planes. Tools and materials have sometimes been delayed for many months.

Research and development have not stopped but rather have been expanded and intensified since the emergency began. New models on the drawing board and test field incorporate the lessons of maneuvers and the battlefield and the ideas of the best ordnance and engineering brains in the nation. Whenever new features represent enough improvement to justify their introduction into production lines, designs are changed. That's the tank story in outline. I am proud of it, and I think you are too!

NOW for the facts about artillery. The United States probably has the most complete line of superior pieces of artillery of any country in the world. These pieces of artillery range in size from the 75-mm. pack howitzer to the huge 240-mm. howitzer.

Classified as divisional pieces used by artillery forces are the 75-mm. pack howitzer, 75-mm. field howitzer, 75-mm. gun, and the 105-mm. howitzer. Of these, the 105-mm. howitzer is a fieldpiece comparatively new to troops and the public. But the 105-mm. howitzer is no new thing to the Ordnance Department. The version of the 105-mm. howitzer that is now in production represents studies and revisions of models that were started some fifteen years ago. At all times over the past ten years the Ordnance Department had complete designs and drawings of a 105-mm. howitzer that could be placed in immediate production pending the availability of funds. The 105-mm. howitzer has been developed to furnish greater fire power for our forces by creating a weapon having plunging fire and utilizing a much heavier projectile with greater destructive effect than the World War 75. Nine commercial companies and three of our arsenals are producing various components for the 105-mm. howitzer, and production has reached the stage where these weapons are being issued rapidly to troops and will shortly become a familiar artillery piece to the public.

For corps weapons, the Army is being supplied with the 155-mm. gun and the 155-mm. howitzer, both of which are familiar to the public. These weapons are being withdrawn from World War stores and modernized by private industry to make them suitable for high road speeds.

Other weapons that are now in production are a 4.5-inch corps gun representing a powerful light weapon suitable for corps artillery as well as antitank missions. There recently has been standardized, and production orders have been placed for, a new modern-type long-range 155-mm. howitzer superior to any type howitzer of this caliber now used in the present war.

For army artillery, the Ordnance Department has in production two companion pieces on interchangeable carriages, the 155-mm. gun, M1, and the 8-inch howitzer, M1. The 155-mm. gun, M1, is the modern version of the old 155-mm. G.P.F. used in the World War, incorporating all new ideas. This weapon has a much greater range and is capable of very high road speeds. The 8-inch howitzer is an army piece capable of firing a 200-pound shell through a plunging trajectory a distance of approximately eleven miles.

Now for the facts of our antitank artillery: The 37-mm. antitank gun is a weapon based upon infantry requirements and represents the most concentrated power that can be packaged in a weapon weighing no more than 1,000 pounds. This weapon is superior to foreign weapons of similar caliber and has been tested side by side with the 37-mm. German gun used extensively in the French campaign. Our weapon, which is very easily handled and fired, has armor-piercing ammunition that makes it effective against the majority of foreign light and medium tanks at close ranges.

At present, a large quantity of 75-mm. guns manufactured during the World War are coming off the production line as completely modernized weapons. This modernization incorporates a split-trail carriage capable of high speeds and immediate emplacement, plus other refinements. This weapon now utilizes armor-piercing ammunition, and with the range and velocity greatly increased over those used during the World War the gun is capable of penetrating the armor plate of any foreign tanks at ordinary ranges. The 75-mm. guns used by the French in 1940 were not modernized and were very inferior to our 75-mm. guns. Further developments by the Ordnance Department have led to the standardization of a light antitank artillery piece having super power. This weapon is capable of knocking out any known tank at very great ranges. The major portion of the parts used in the manufacture of this gun are already in production as components of other ordnance items.

WITH regard to gun mounts, *the Ordnance Department of the United States Army was the first in the world to manufacture self-propelled artillery.* As early as 1926, the Ordnance Department had completed the manufacture of several self-propelled mounts for various calibers of artillery. With the decided change in tactics used in the present war in Europe, it has been necessary to develop self-propelled artillery for various missions. Of course, it is known and realized that the best defense against a tank is another tank. However, the great cost and time of manufacture of tanks makes it necessary that self-propelled antitank weapons be used. In many cases, self-propelled artillery is being developed to perform definite missions other than for use against tanks.

With the aid of the automotive industry, this second phase of development of self-propelled artillery by the Ordnance Department is proceeding at a rapid pace. An example is the 75-mm. "tank destroyer," a 75-mm. gun mounted on a half-track vehicle. Only seventy-five days were consumed from the time this idea was conceived to the time units were actually in the field.

May I say, in passing, that besides building all types of aircraft armament for both the Army and Navy, the Ordnance Department has in production, here in Hartford with the Colt Company, the powerful 37-mm. aircraft cannon—placing the United States well ahead of all European countries in the use of aircraft cannon.

The self-propelled artillery program is extensive, and the Ordnance Department has brought thirteen different manufacturers into this work. This program calls for the mounting of all sizes of artillery, starting with the 37-mm. gun up through and including the huge 155-mm. gun. Commercial parts as well as parts of tanks that are in production are being utilized almost exclusively. With the new program calling for the manufacture of huge reserves of artillery and tanks there are to be manufactured several thousand pieces of self-propelled mounts, all of which are ready for almost immediate production.

Next in order is antiaircraft artillery. Antiaircraft artillery is expensive and intricate to manufacture, and funds avail-

able prior to June 1940 permitted production of only small numbers of guns. However, our Ordnance Department had recognized the great importance of antiaircraft artillery and prior to the emergency had developed and manufactured, within the limits of appropriations, the very effective 3-inch antiaircraft gun. Experience to date in Europe has shown that most effective antiaircraft work has been done at altitudes of approximately 12,000 feet. Our 3-inch gun is very effective at this range and has a far greater ceiling.

At the beginning of the present emergency, designs were already made for the production of the longer-range 90-mm. antiaircraft gun. Pilot models had been made and tested, and the gun is now in quantity production. The reports from our observers abroad indicate that this 90-mm. gun outclasses in accuracy and range Germany's corresponding aircraft weapon—the 88-mm. model.

Not content with that achievement and foreseeing bombing attacks from the stratosphere, the Ordnance Department some time ago began designs of a new antiaircraft weapon considerably larger and more powerful than any yet manufactured. Development of this weapon has approached completion. Production can be started in the near future. Smaller caliber antiaircraft guns are needed for protection of troops against low-flying aircraft. This protection is provided by the caliber .50 antiaircraft machine gun, the 37-mm. antiaircraft gun, and the newly adopted 40-mm. Bofors gun.

FINALLY, let us consider infantry helmets. The helmet used by American troops in the last war was copied from the British-model helmet which had seen three years of action on the Western Front, and it was hastily put into production in this country.

As early as November 1920, action was taken by the Ordnance Department to develop a helmet of superior type to replace the British model. Over a period of six years, extensive tests were conducted by the Infantry Board, in cooperation with the Ordnance Department, on six helmets of varying shapes and materials, including the World War model, 1917. Experimental helmets were principally of a pot-shaped design similar to that of the German helmet. This design presents a surface nearly normal to the trajectory of a small-arms projectile and is, therefore, not as effective ballistically as the sloping surface of the M1917. A helmet known as type 5A was found to be the most promising of the new type, but in ballistic tests did not compare favorably with the M1917 helmet.

Another group of experimental helmets were tested from November 1930 to June 1932 but likewise were found to compare unfavorably with the M1917 in ballistic properties. Additional tests were conducted in 1930 on helmets of Swedish design and also on an American-made helmet. In these tests also, the M1917 helmets proved superior to the experimental types. In view of the fact that the M1917 helmet was considered superior by the Infantry to any of the various experimental helmets developed up to that time, in June 1934, the Army standardized the M1917 A1 helmet which was substantially the M1917 helmet with an improved liner.

During the period 1934 to 1940, the war-time 1917 helmets were renovated by the application of the later and improved type of liner. In November 1940, upon recommendation by the Chief of Infantry, the Ordnance Department renewed its efforts to develop a helmet of superior design. As a result of this development, a helmet similar in shape and general design to the 5A helmet previously rejected was produced. It incorporated all the desired characteristics specified by the Infantry as to shape, protection, and comfort, although it was somewhat heavier than the 1917 A1 helmet. The principal improvement in the new helmet over the 5A was in the lining and suspension. The improved lining and suspension were outgrowths of those used in football headgear.

This helmet underwent extensive tests by both the Ordnance Department and the Infantry. In testing all experimental helmets, the opinions of the soldiers using them were a prime consideration. The results obtained culminated in the recommendation by the Chief of Infantry to adopt this helmet, and it was standardized as "Helmet, Steel, M1." These helmets are now under quantity production. That's the helmet story, complete and unabridged!

These are the facts about six of the principal categories of ordnance. Next time you hear some unfriendly critic misstate any of those facts, you will be doing a real service to the Ordnance cause if you will take it upon yourself to put the record straight. This job of making armament for the national defense of the United States these days is entirely too serious and entirely too important to have any one phase of it misunderstood by anybody, anywhere, at any time.

I wish to express my gratitude, on behalf of the Ordnance Department of the United States Army, for the splendid help of the Hartford Ordnance District. Without this assistance we of the Ordnance Department would be somewhat in the position of Gen. Robert E. Lee when he heard that Stonewall Jackson had lost his left arm—General Lee's message was: "You have lost your left arm, but I have lost my right." So would it be for me as Chief of Ordnance without the fine help of American industry in the present arms-production undertaking. I depend upon you to continue in the same fine spirit in which you here in New England have carried on the Ordnance tradition from the very infant days of our Republic. At no time have you meant more to the national defense of our country than now. Stand by your guns!

EDITOR'S NOTE.—Subsequent to the delivery of the above address, the War Department announced on November 27, 1941, the beginning of a large steel cast tank program. This expansion program, totaling $53,500,000, is for the construction or expansion of rivetless armor-casting facilities. According to a report of the Chief of Ordnance to the Under Secretary of War, these new facilities are required to provide for cast-steel tank hulls and tank turrets. These hulls and turrets will be required to carry forward the enlarged program for the production of the new medium and light tanks. Commitments already have been made with five manufacturers, and negotiations for other facilities are in progress.

General Wesson reported to the Under Secretary that production plans for some time have contemplated the complete elimination of the riveted type of construction on all combat vehicles. He further reported that cast-steel hulls are now being made in considerable quantities for the medium tank and that this type of hull is being used increasingly. A minimum of thirty per cent of future production will have the cast-steel hull. The balance will be of welded construction. The development of cast armor plate and the use of welding puts American tank construction far in advance of any such construction known. The methods have been developed as the result of many experiments on light tanks. The War Department expects that in due time all work on the medium tanks will be either welded or cast.

Armament Production

A Progress Report on Ships, Aircraft, and Ordnance

William H. Harrison*

AT your annual meeting last year, Mr. Knudsen gave a report of the status of the defense program, and it has been suggested that I bring this up to date. A year ago the concept of the program was to train and equip an army of 1,400,000 men, provide strategic materials and supplies for a larger force, build ships to round out a 2-ocean navy, and provide for an expansion of the merchant-marine fleet. In all, expenditures of $28,000,000,000 were in sight.

Now the concept is to: (1) Provide for a considerably greater military force of our own; (2) Advance the building of the 2-ocean navy; (3) Accelerate production to serve as the "arsenal for democracy"—*i.e.*, turn out munitions, materials, ships, and supplies for Britain, Russia, China, and their allies, and (4) Provide for the bottoms to make possible the handling of much of these supplies.

Expenditures of something over $60,000,000,000 are in sight, and the trend is upward. Thus far, over a quarter of it is for ordnance material. Underlying all this activity is the very sound philosophy that every effort should be made to hold at a minimum the disruption of the going way of civilian needs.

At the present time, upward of 1,500,000 men are in training. They are well housed and reasonably well equipped with basic training implements. In large measure what they lack in equipment grows out of the urgency of Lease-Lend needs.

On the Navy side, each month sees a substantial number of new combatant vessels and auxiliaries added to the fleet. You know of the two new battleships recently made ready for fleet service and of the launching of two new high-speed cruisers. The number of destroyers, submarines, and patrol craft completed this year will be reassuring. At the present rate of progress, a balanced 2-ocean Navy will be a reality well in advance of any estimates previously thought possible. Two figures help spell out the magnitude of the naval job: The present fleet totals 1,250,000 tons; 2,250,000 tons are to be added.

The completion of new merchant vessels is now at the rate of eight 10,000-ton cargo vessels a month, and a going rate of over fifty a month, or nearly two a day, should be reached by the middle of 1942. Better than a million tons will be completed in 1941—five to six million in 1942. The significance of these figures becomes apparent when it is realized that our present merchant fleet totals some ten million tons.

All the romance of ships is not to be found on the sea. There is much of it in the building of the operating bases and the construction of new facilities for the expanded naval and merchant fleets. Little is heard of this—such a striking job has been done that no one talks of it.

In aircraft, September's production totaled 1,914, and the majority were of the tactical type with a substantial number of 2- and 4-engined bombers—the latter, of course, being relatively few. While September production in numbers was more than half the estimated maximum monthly objective, it would be misleading to give the impression that the over-all job is beyond the halfway mark, because this is not the case.

MEASURED in terms of the yardstick of manufacturing effort, current output, gratifying as it is, represents but a third of the ultimate effort. The reason for this is that as the program progresses, the proportion of heavy bombers in relation to the total grows greater. Detroit represents the hub and the spokes of this bomber program; the tying element—the rim—is principally at the assembly plants at Fort Worth, Tulsa, Kansas City, and Omaha. There is a challenge in this bomber job exacting enough for the best in this area.

In ordnance and directly related items, the phase of the program involving the construction of new plants and arsenals is well advanced. In round figures, a total of seventy special-purpose plants is contemplated. Work is under way on substantially all—in fact close to thirty now are in partial or complete operation—and additional units are being made ready each week. The sum of $1,250,000,000 has been appropriated for construction of these plants.

Small arms, machine guns, and smokeless powder can be singled out as being abreast of schedules. Antiaircraft, antitank guns and field artillery, TNT, director and signaling equipment are not up to needs, and small-arms ammunition, despite the record of construction of several new plants, continues to be urgent.

Tank output is sizable, and within a few months the going rate should be well over half the present estimated maximum. On the other hand, Lease-Lend need for tanks is pressing; this is a phase of the program that is in for vast expansion and extreme pressure.

Referring to tanks, I think those who visited the Detroit Arsenal will agree that they saw the best in engineering skill, machine tools, management, craftsmanship, pride in accomplishment, and a full sense of defense consciousness, all brought to bear on a single purpose—and with what grand results: A pasture a year ago—today an arsenal worthy of all who had a hand in its accomplishment and a symbol of the perfect blending of government and business in an emergency!

You will understand my inability to give specific figures. You may be sure, though, that over-all production in most instances is well up to expectations and well in advance of any yardstick that might be applied in relation to World War effort. For example, defense expenditures in September amounted to $1,400,000,000. On the other hand, results are far from satisfactory, and I shall touch on this in a moment or two.

UNDERLYING all this striking performance are years of careful, long-range planning by the War and Navy Departments. And, in the midst of current activities, little recognition is given to that forward-looking approach. Members of the Army Ordnance Association, of course, realize that the

*Director, Production Division, Office of Production Management.
This is an address delivered at the Annual Dinner, Twenty-Second Annual Meeting, Army Ordnance Association, October 9, 1941, the Book-Cadillac Hotel, Detroit, Mich.

road thus far covered could not have been gained had not this far-sighted planning been carried on over many years. In substantial measure, this is the fruit of your effort, and progress to date must be gratifying to your Association.

NOW that defense machines are swinging into volume production with their endless appetite for materials, many industries are faced with immediate curtailment because materials must be diverted from normal channels. I am not going to attempt to review what is being done to search out substitutes and to find new and additional sources of materials, but you may be certain intensive work is being done along all fronts. On the other hand, there are two considerations growing out of this that call for emphasis. The first is the use of critical materials themselves, and, in this, each of us in direct defense work has a continuing responsibility to insure that such materials are not used where available substitutes can be soundly employed.

The fact that defense operations enjoy preferred priority classification, with consequent preferred claim on materials, emphasizes the scope of our responsibility and the opportunity for effective conservation. Every use of a scarce material ought to be carefully scrutinized and considered judgment exercised to insure minimum use of it and to insure a minimum of scrap and wastage. Along with this, of course, close inventories are essential. Whatever your ingenuity can do to stretch critical materials may be the salvation of a plant and its employees. It is worthy of your best effort.

The other underlying consideration has to do with broadening the base of the defense work. Mindful as I am of the extent of present subcontracting and of the constructive approach that has been made to this by the several governmental departments and by many of the prime contractors, particularly Ordnance district offices, yet I think it clear with the program ever expanding—with consequent dislocations of business—that a still further spread can be made to advantage all around.

Naturally, in any broadening of the base there are considerations bearing on the credit side and some on the debit side. Experience demonstrates that the pluses well outweigh the minuses and that many of the minuses spring from practical difficulties—and no one will deny such do exist. An equitable and adequate solution can and will be found.

Most people in the current work know of the long-range, effective effort in subcontracting and realize full well that had this not been so you would not have found the machines, the tools, the factories, the labor, and would not have reached the present gratifying rates of production. None the less, even at the risk of being thought unmindful of all that has been done, I am certain we must broaden out still further to insure accelerated production.

Faced with a job where results are never good enough—where management, labor, material, and Government agencies all must be reckoned with every and any day—a job that tries the most resolute of men—you who have been at it know that there are times of satisfaction and times bordering on despair. Probably our greatest continuing satisfaction in OPM springs from the leadership of Mr. Knudsen—his capacity, inspiration, and steadfast devotion to the job. And along with this is the generous consideration our staff receives from you men out where the work is done. Captain Gawne, Mr. Johnson, Mr. Britton, Mr. Meigs, Mr. Kahler, and I all express appreciation and reiterate our readiness to be of service to you.

There is a frosting on most things good. The frosting that makes life really livable at Washington these days is the constant reminder, manifest in numerous, varied, and sundry ways, of consideration for us by General Wesson, General Gregory, General Harris, and their staffs, many of whom are here tonight.

We have talked mostly of physical things—airplanes, tanks, etc.—but after all, these are but the product of the will and effort of men and women—the capacity and inspiration of management—the ingenuity and resourcefulness of science and engineering—the interest and understanding of the public.

When I made the suggestion a few moments ago that production results were far from satisfactory, the reason for this observation was not that results broadly have not been all they might have been, but rather because we are in a race against time—tomorrow may be too late. World events both mock and dramatize the extreme need for speed. Every day that passes is a day never to be reclaimed.

No matter what one's political, social, or labor theories may be; no matter whether one clings to the isolationist theory or the reverse; no matter whether one thinks in terms of social or business gains; no matter whether one is concerned with the affairs of today or with the world of the aftermath, as individuals—as a nation—we can't brush aside the shocking fate of those who were weak—who were unable to withstand the brute force of the aggressor's machine. What a tragedy it is when, on the one hand, we see all this horror standing out in bold relief, and, on the other, we are unable to discipline ourselves to make the most of these days which are so precious—precious, because we share them only with ourselves.

TO my mind there is now no conflict basic enough in the whole range of our complex social and economic behavior to justify even a single day's loss of production in the implements of offense and defense. They speak the only language the aggressor understands. No matter where we might have sprung from in life—the North, the South, the East, the West, foreign shores; no matter whether we are farmer, laborer, butcher, baker, candlestick maker, we've had handed down to us, hard-won by blood, heart, and sacrifice, a priceless heritage.

Along with that heritage, our generation is gifted with everything that goes for being ready for whatever tomorrow may bring forth—materials, skill, imagination, and resourcefulness in labor and in management, in science, research, and engineering. We have grand leadership in the Army and Navy—General Marshall and Admiral Stark and their staffs are equally ready in this grave responsibility which is theirs.

To bring our blessings into full play—and God knows we have a generous store of them—we need a little stronger "will to do," more determination on the part of all of us, a little more tolerance and understanding by those of us thrown into that sensitive, delicate melting pot we call capital and labor, industry and Government. The challenge is with each of us.

EDITOR'S NOTE.—In an effort to facilitate the spreading of defense work into additional plants, the Contract Distribution Division of OPM made public an Army compilation of existing contracts which seem to offer the greatest subcontracting opportunities. The Army compiled the list after a request that it review items currently under contract.

Antiaircraft Gun Carriages

Manufacture of the 40-mm. Bofors Mount

J. E. Trainer*

IN these troubled times, when our country is mobilizing its resources, its energies, and its industries to make the United States the arsenal of the democracies, we find refrigerator manufacturers making machine guns, automobile manufacturers making cannon, and tire manufacturers making gun carriages. For example, the Firestone Tire & Rubber Company is making tires and tubes of all types and sizes for every branch of the service and, in addition, is manufacturing hundreds of other items made from rubber and steel for our armed forces—gas masks, barrage balloons, bullet-sealing fuel cells for airplanes and armored vehicles, life belts, life rafts, rubber track blocks and bogie rollers for tanks and half-tracks and other items too numerous to mention. A subsidiary, the Firestone Steel Products Company, is now engaged in filling the world's largest contract for caliber .50 machine-gun bullet links as well as many other defense products made from steel. And it recently has developed a revolutionary new type of shatter-proof oxygen tank for high-altitude flying.

Long before the present emergency developed, the Firestone organization began working with the Ordnance Department in anticipation of the future. About seven years ago, when public and political sentiment forced our Army to subsist on extremely small budgets, the Ordnance Department pioneered a new idea in the design of tracks for Army tanks. This new type of tank track consisted of a rubber-covered steel skeleton with precompressed rubber joint bushings. These articulated rubber bushings eliminated the need for metal-to-metal bearings and thereby solved the problems of lubrication and dirt exclusion which are inherent with bearings of this type.

This type of track flexes as it moves around the sprockets and idler wheels, and it conforms to the contours of rough terrain. It withstands terrific stresses and cushions the shock loads throughout the entire drive train. The almost perfect elasticity of rubber is so utilized that energy stored in the rubber while flexing in one direction is given back at a later point in its cycle, thus yielding a low rolling resistance and resulting in a considerable saving in power.

The track for the pilot vehicle was built by Firestone, and its performance and service life were extremely gratifying to the Army. But this pilot model weighed only seven tons; with heavier armor, greater power, and other design changes to increase its striking power and resistance to shell fire, it was necessary to undertake a job for which American engineers are famous, namely—to build 'em bigger, better, and cheaper. To meet these new conditions, the track had to be strengthened and made relatively lighter. Above all, these improvements had to be made with practically no changes in design which would involve expensive alterations and tools or long and expensive test programs, because the Ordnance Department was operating on a budget which would now be considered "petty cash." Appropriations had to be spent cautiously, and the rubber industry, along with many others, contributed generously of its own funds and talents toward defense—and this was back in 1934.

NOT all our mechanized and motorized equipment runs on continuous tracks. In fact, by far the largest percentage of it moves on pneumatic tires. During the World War, pneumatic tires for trucks were still being developed and had not reached that stage of reliability which rated their consideration for military vehicles other than passenger cars and ambulances. You will recall that Quartermaster trucks used solid tires while gun carriages were equipped with either steel or solid-rubber tires. Today, practically all vehicles in the service run on continuous tracks or pneumatic tires, making it possible for them to move at the same high speeds and with the same efficiency as regular commercial transportation. Naturally, pneumatic tires must be protected against punctures by small-arms fire or shell fragments, and the rubber industry has developed two ways of providing this protection.

The first method consists of an innertube containing inside it a layer of plasticized rubber which is more or less the consistency of chewing gum. This acts as a self-sealing material should the tube be penetrated by anything less than a good-sized explosive shell. When a bullet goes through an inflated tire, the plastic rubber instantly flows into the bullet hole and effectively seals the tire against all but a small loss of air.

The second method is based on the idea of not trying to hold the air in the tire after a bullet has gone through it, but rather to reënforce the casing in such a way that even without any air in the tube the casing can still run for a reasonable distance at speeds as high as fifty miles per hour under full load. This basic idea has been used with success by the British, and recent improvements developed by American manufacturers make it possible for this type of tire to run more than one hundred miles fully loaded when deflated. This is considered sufficient to keep the vehicles in active service until a convenient time for replacing the tire or tube develops. Actually, in demonstrations, fully loaded vehicles have been driven distances up to 1,500 miles with no air in the tubes—the added deflection after being deflated amounting to only fifteen per cent.

In addition to the problem of designing a casing which will not collapse completely when punctured, there has been the additional task of developing a means of anchoring the beads of the tire to the rim so that the torque of the engine or the braking effect of the brakes can be transmitted through the tires without causing them to slip on the rims. This led to the development by our engineers of a new type of rim and a metallic locking device for anchoring the beads of the tire which have proved to be notable contributions to the cause of national defense. These tires, when operating over rough terrain, actually give greater traction when deflated than when properly inflated.

So far, I have mentioned only those products of rubber

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This is an address delivered at the Ordnance Production Session, Twenty-Second Annual Meeting, Army Ordnance Association, October 9, 1941, the Book-Cadillac Hotel, Detroit, Mich.

PROOF FIRING THE 40-MM. BOFORS ANTIAIRCRAFT GUN ON MOBILE CARRIAGE

and steel which, although they are strictly defense items, are distantly related to the line of products that we make in normal times. Now I would like to discuss one of the more unusual activities of the Firestone Company—the manufacture of mounts and carriages for the Bofors 40-mm. antiaircraft gun.

LONG before the present emergency developed, the Army Ordnance Department surveyed all manufacturing plants in the United States. This was done to determine their ability to expand their natural lines of business to take care of emergency requirements and also find out just what these companies could do outside of their regular commercial lines during an emergency. This is a typical example of the long-range planning done by the Ordnance Department before the present defense program.

When the surveying committee visited the Firestone Tire & Rubber Company at Akron, Ohio, they found one of the world's largest establishments for manufacturing tires and other rubber products built on a site of 150 acres. In addition, they found the plant of the Firestone Steel Products Company with 192,000 square feet of floor space, turning out approximately 40,000 tons of steel products per year. But the biggest surprise was a machine shop with 110,000 square feet of floor space, fully equipped with modern machine tools and employing 900 men, doing extremely accurate work of all kinds in the manufacture of molds, dies, and machinery developed and designed by the Firestone organization for its plants throughout the world. At that time, the Ordnance Department undoubtedly recorded in their survey that here was a plant which might be called upon to do an unusual job when and if needed.

Early in the present emergency, our company volunteered the use of its facilities to undertake the manufacture of any special defense products that the Government considered us qualified to make. As a result, early in February 1941, Lieut. Col. H. M. Reedall, executive officer of the Cleveland Ordnance District, asked us to meet with him and two other manufacturers at Frankford Arsenal, Philadelphia, to inspect a 40-mm. Bofors antiaircraft gun mount that had just been received in this country from abroad.

The Firestone Company was given the contract calling for a complete set of drawings covering this mount, from which we were to produce two pilot models. The Chrysler Corporation was selected to manufacture the gun tubes and breechblocks. The Government made the imported mount available to us together with a miscellaneous lot of English and Swedish drawings all of which were in millimeters and first-angle projection. Our first job was to transpose these to United States Ordnance standards. We were advised that we were at liberty to suggest and recommend design changes to facilitate production and to improve the operation of the mount, and I want to mention here that we had the finest kind of coöperation from the United States Ordnance Department in weighing the various suggestions that we made and in arriving at the final approved design.

It might be well to mention how effective some of these changes were: All the frame structure of the original Bofors gun was riveted, requiring over 1,000 rivets. In the redesign, we adopted welded construction, thereby producing much more rigid elements with a saving of fifty man-hours per mount. In the case of bearing parts, which called for manganese-bronze bushings, we saved approximately 250 man-hours per mount by substituting "Oilite" bushings in places where their efficiency had already been established in American practice.

The traverse mechanism under the mount in the original Bofors carriage consisted of a double-constructed ball bearing providing for no radial thrust, this being taken care of by a trunnion and bushing in the center of the mount. In the redesign, we specified a single ball combination thrust bearing, eliminating the trunnion and bushing, which re-

sulted in a saving of nearly 480 man-hours per mount. In addition, we were able to reduce our prime machine-tool investment for this one item by about $300,000 which was of great importance in view of the present shortage of machine tools. In many cases, fabrications have been substituted for difficult forgings. For example, the axles on the original mount were forged and afterward machined and bored for lightness. The new design is based on the use of steel tubing and a welded construction. This not only saves many man-hours but also eliminates an expensive die and tool charge. The carriage is also now equipped with electric instead of hydraulic brakes.

THIS first phase of the job, requiring a total of 1,600 drawings, covering the 1,485 individual parts of the mount, was all done in an isolated drawing room which we made available for the project, taking draftsmen from our various engineering departments to make up the backbone of this organization. This department, when operating at the peak of the job, employed approximately one hundred draftsmen and engineers.

The second phase was building the two pilot models to the new drawings and specifications. At this point I want to add that the coöperation we received from the Ordnance Department in changing the English and Swedish specifications to American standards was one of the things that made it possible for us to deliver these two pilot models to the Government slightly more than four months after work was started.

The third phase of the job dealt with the design and production of jigs and fixtures for putting the work on a production basis, plus the subcontracting of parts of this mount, thereby holding to a minimum the amount of new equipment that would be required to produce the mounts at the rate of five a day—a schedule which later was increased to ten a day.

One scheme found to be particularly effective in dealing with subcontractors was the mounting of component parts on a display board which enabled them to see the actual parts under discussion. In most cases we found it preferable to assume the responsibility of furnishing subcontractors with raw materials since our purchasing power and knowledge of procurement were of definite advantage in cutting costs and expediting deliveries.

In designing jigs and fixtures, both for ourselves and for some of our subcontractors, emphasis was placed on securing maximum accuracy through the use of the jigs and fixtures themselves when using semiskilled workers or unskilled workers being trained specifically for this job. We are able to report that ninety-five per cent of our jigs and fixtures are in use, and parts are being produced in strict accordance with the specification.

During the time we were building the pilot units and preparatory to starting production, we set up a school in our plant in Akron to train machine operators. This school was established in conjunction with the Akron Board of Education, working with the National Defense Training Program. The young students were intensely interested in learning a new job and very quickly picked up the specific operations on which they were being trained. This method of developing personnel, plus the transfer of a large number of skilled mechanics made possible by curtailment of regular machine-shop operations, will enable us to meet our labor requirements for our production schedule.

FOR the production phase of the job, our machine shop has been expanded and those parts requiring the greatest accuracy in machining operations are being manufactured by us. These comprise about forty per cent of the larger components involved. The balance of the work has been subcontracted to smaller manufacturers and machine shops, mainly within the Akron area. Only through the wide scope of our subcontracting activities could we avoid the necessity for prohibitive expenditures for machine tools and meet the early delivery schedules. As a result, we are now doing business with more than 300 suppliers and subcontractors.

In approximately 50 working days we constructed an assembly building of 200,000 square feet into which the parts from our own shops and subcontractors are brought together and assembled into the final units, our assembly lines being so arranged that we can, if required, readily produce 20 mounts a day.

Inasmuch as we have subcontracted a considerable portion of this work, the handling and expediting of the subcontractors become a very important part of our job, and engineers from our own organization have been assigned to the various subcontractors. These men are held individually responsible for the production schedules of these subcontractors and the accuracy with which all parts are fabricated in accordance with specification. These engineers whom we have assigned to subcontractors become, in effect, their production men on our jobs, planning and laying out the work by operations and dates and assuring the flow of finished components to our assembly plant. In order to do this, they must check to see that the man-hours are being applied regularly on our work and that every part is making its proper progress through the shop.

When bottlenecks have occurred in procuring raw materials and standard parts, we have had excellent coöperation from the Cleveland Ordnance Office in bringing to bear the necessary pressure to improve deliveries. As previously mentioned, all parts of our job are now in actual production, and finished gun mounts will be coming off our line at the rate of ten a day in January.

From the very beginning, the lure of the job, the challenge to our ingenuity and skill, has been an irresistible urge that inspired the entire Firestone organization. But the hardest part still remains to be done; that is, to keep the mounts rolling off the production line.

EDITOR'S NOTE.—Characteristics of the 40-mm. antiaircraft cannon were described in the last issue of this journal in an article by Maj. Daniel J. Martin, chief, Cannon Section, Office of the Chief of Ordnance (ARMY ORDNANCE, November-December 1941, Vol. XXII, No. 129, p. 386). General data of the 40-mm. gun are as follows: Rate of fire, 120 to 140 rounds a minute; weight of gun in firing and traveling position, 4,300 pounds; maximum range, 11,000 yards, horizontal; weight of projectile, 2.205 pounds; weight of powder charge, 0.628-pound; weight of fixed cartridge, 4.63 pounds; muzzle velocity, 2,850 feet a second; vertex for time of flight of 11.5 seconds, high-explosive tracer shell, 5,391 yards; range for time of flight of 11.5 seconds, high-explosive shell, 5,413 yards; gas pressure, maximum, 42,630 pounds per square inch; elevation field, minus 5 degrees to plus 90 degrees; traversing field, 360 degrees; length of recoil, 7.874 inches; wheelbase, 125.98 inches; maximum vertical range for 11.5 seconds, 5,391 yards.

The Detroit Tank Arsenal

The Chrysler Plant for Mass Production of the Medium Tank

K. T. Keller*

IT has been apparent to almost every one who has given serious thought to the situation that a war has been developing in Europe with all the indications of being perhaps the biggest war that ever struck this world. Any one running an efficient and capable manufacturing institution did not have to think more than three minutes to realize that the United States would improve its defense armaments and that this could not be done without the enthusiastic, sympathetic, and active coöperation of American industry—particularly that part of industry which deals in metals.

Because the necessities of war have passed far beyond anything seen in the World War twenty-five years ago, those of you who, like myself, had an active part in that conflict and are taking an active part in this one, realize that there is practically no similarity between them. True, in those days they were talking about manufacturing and mass production having reached a marvelous state of perfection in the automobile industry, but we would have been in terrible shape then to tackle a job such as we have to do today. Now, we manufacture to a quarter of a thousandth of an inch in dimension as easily as we did to a thousandth or a thousandth and a half in those days. Why is this so? It is because many mechanical minds have been concentrating for twenty-five years on the development of methods and machines and tools that would make a finer product and make it easier.

Twenty-five years ago we were looking for lathe hands, drill-press hands, and milling-machine hands. Those who took on war work were scouring the country for trained workers so that we had a great migration of skilled labor. Today, that has almost disappeared, with a few exceptions, perhaps, such as toolmakers and pattern makers and men of that character.

Why has it disappeared? Because the mechanical engineers of industry have taken the problem of accuracy and have built it into the machines and the tools. In a modern shop today, tools are all preground—you do not find a grinding wheel standing around near a machine tool for the operator to sharpen the cutting tools. In an automobile plant today, the man who tends the tools does not grind them. They are ground to predetermined gauges with as close accuracy in dimension as is expected in the finished piece. Changing a tool in a lathe is just as simple as loosening a nut, putting a new tool in a fully machined holder, and with the feel of the finger getting it level on top (the finger can detect a variation of a quarter of a thousandth of an inch) and then tightening up the nut and letting her go.

Not only has the art of manufacturing tools for cutting metal advanced to this state, but the useful life of the tool has been predetermined so the operator knows exactly how many pieces he is going to do before he takes the tool out of the machine. The perfection of this art of building the quality into the tools and determining their safe life between sharpenings has paid big dividends. As an illustration, a cutter which cost about eighteen dollars will cut safely about fifty gears before becoming dull. Maybe one cutter will cut sixty, maybe one will cut fifty-four, maybe one will cut seventy. But if the cutter is taken out after cutting fifty gears, about three- to four-thousandths of an inch ground off its face puts it back into useful service. If the cutter is run until it fails, an eighth to three-sixteenths of an inch must be taken off the face in sharpening before it can be put back on the job.

That is a real conservation of equipment, time, and material, because in that three-sixteenths of an inch is the capacity to cut thousands of gears; so why waste it by getting twenty more than the safe margin of fifty that has been set?

The automobile business has found and located by experience such economies which we now are trying to apply to a line of materials totally strange to us. Of course, any institution is a matter of the people that are in it: no brick walls, no cast iron, no high-grade steel, and no electric lights ever produced a thing. They must be in control of the man who has a mind that is in tune with the responsibilities placed on him. And, it seems to me, that to take that responsibility, he first has to realize what it is—just what does his boss expect him to do? And he cannot bring himself to that state of mind unless at the same time he is willing to recognize the authority of the man above him and to have confidence that the man on the next machine also will do his job well.

THAT brings us to the 28-ton tank which you will see being manufactured this afternoon. To keep the record straight, the Chrysler Corporation started in the tank business about the end of March 1940. At that time, the executives of the Chrysler Corporation laid before the board of directors their opinion that this matter of defense would be a very important one and that it could not go forward without the Chrysler Corporation sooner or later taking an active part in it. We received instructions from the board of directors at that time to take the jobs we could do with satisfaction to the Government and with credit to the corporation.

So when Mr. Knudsen said to me one Sunday morning in June, "Will you make tanks?" I was able immediately to answer, "Yes," because we had the entire executive organization of the Chrysler Corporation and the board of directors, who represent the stockholders, behind us. We did not have to go back and place the proposition before any one to get instructions, so what might otherwise have required several hours' discussion, took only a few minutes.

We approached this job from the standpoint of having a responsibility to our men, to our stockholders, and to our country, and, in less time than you could write about it, we had some of our men at the Rock Island Arsenal. There we saw this fearful and awful thing which was an 18-ton tank, and took a ride in a 10-ton one, and discovered how entirely different it was from anything we had ever built. But we looked it over and decided that we could be as good as the Rock Island Arsenal if we just made up our minds we were going to be, and if they could make it so could we!

*President, Chrysler Corporation.
This is an informal address given at the Industrial Mobilization Luncheon of the Twenty-Second Annual Meeting, Army Ordnance Association, October 9, 1941, the Book-Cadillac Hotel, Detroit, Mich.

We left a man there to get the blueprints, and he got back the next Sunday morning. What a roll of prints those were! They were as big as the man that brought them. They weighed a 186 pounds and there was just one print of each part. We took a look at them and found that some of them were in eighth scale, some were in quarter scale; we said to Ed Hunt, now operating manager of the tank arsenal: "Ed, it's going to be pretty hard for the gang to work from these prints. First thing you know some fellow'll think he's making a piece about as big as he can hold in his hand, and he'll find that it'll take a 5-ton truck to haul it. We can speed this up a lot."

We got the pattern maker and told him: "Here's a job. We want all these pieces made out of wood, and we want you to drill all the holes and put them all in—then shellac them and deliver them up here to Hunt."

It took about fourteen days to make the pieces. We started putting them together to see whether they would assemble readily. Imagine our surprise—they went together without having to scrape or file any of the shellac off the wooden parts! We had a purpose in having those pieces shellacked; if any of it was scraped off, we could see immediately where a piece did not fit. The pins for assembly were made with about a sixty-fourth clearance, and they went right into those rivet holes and stuck that tank model together. It was really remarkable. Right then and there we said, "They have a good design department somewhere in Ordnance." A little while later we met General Barnes. He is here, and he is O.K.!

ABOUT that time we saw we were really in for something. So we got the plant managers in and said, "What's your master mechanic doing?" Of course everybody was busy, but we pried about fifty fellows loose from their regular jobs. First, we got those men started, and in about four or five days the plant managers got used to being without them so we went back and got fifty to sixty more. Inside of 3 weeks, we had 380 men on that job. These men were men out of the master mechanics' department and many of them were head master mechanics themselves. I do not think there was a man in that preliminary tank organization, unless it was a boy to carry the blueprints, who was getting less than $300 a month. We had them from there up to $20,000 a year.

We decided to give Ed Hunt the job of getting the plant tooled. If he tooled it well, we would give him the job of running it. We are great believers in getting a fellow to work up a plan and then, after he has worked it up, telling him to take it and make it work. There is something in that plan which seems to get about the best out of a man. Well, we are still struggling along, but we are getting there—and Hunt is running the plant.

We then came upon the problem of how much of a building we would need. At that time there was no Lease-Lend or Defense Plant Corporation or 5-year amortization. The Army was given only about a third as much money as it would have liked and it wanted to put that amount into tanks—not buildings. We talked the matter over and agreed it was a pretty tough proposition with a good many million dollars involved.

Then I recalled the job of cleaning up some contracts after the last war and the time and the discussions we had on them. We hit upon a plan and went to Washington with it. Much to our surprise, General Wesson said, "That's just exactly what I wanted." As an illustration, during the last war our Dodge division built a plant and made the recoil mechanisms for the 155-mm. cannon. After the war was over, the Army said to Dodge, "We would like you to take the building off our hands."

John Dodge said he did not think so much of the building and did not want it, but they begged him to take it. So he got the building for about thirty cents on the dollar. Then the Army boxed up all the machinery and equipment and sent it out to Rock Island Arsenal for storage. When they were all through, I venture to say that they spent more money boxing up that machinery, shipping it out there, and providing a place to store it, than they got for the building in which it had been operating in Detroit.

So we said to General Wesson: "Tanks are a new weapon in the Army. They need a home. Why don't you have a tank arsenal? You're going to need a place, until something new comes along, where you can design, test, and build tanks and where you can keep them in repair. Now, why not put this piece of apparatus in the city of Detroit, alongside a pool of labor such as we have in the Chrysler Corporation—from car unloaders to metallurgists who fit this kind of job. Have that all set up and ready to run about the same as you pipe water into the shower in your bathroom. When you want tanks, we move over and make tanks; when you don't want tanks, we move back and, pray God, we make automobiles." He said, "That's exactly what we want."

THAT is how the tank arsenal happens to be the kind of institution it is and happens to be where it is located. You are going to see this arsenal this afternoon. It now is operating at just about fifty per cent of what we expect it to do. Soon we are going to double it. It is going to be quite a nice race to see if we get the present section to one hundred per cent capacity before we get to the point where we double it. But apparently there is no end to the problem. So far as the executives of the Chrysler Corporation are concerned, they are going to continue to spend some sleepless nights and a good bit of their time, figuring how to get out more and more and more tanks. But after all that is the history of war.

I do not see how you can divorce the interests of the man on the street and the man at the desk and the man at the machine from the interests of the men in Washington who are laying out these tanks and spending this money. We may have a difference of opinion as to the methods used; we may have a difference of opinion as to whether the job is being done right; we may have doubts as to whether we are on the right track, in every particular and at all times. But there is one thing I have no doubt about at all and that is that the U. S. Government needs tanks—good tanks—and that the people of this country have placed their confidence in the Chrysler Corporation to be one of many suppliers on that program. That is the job we are going to look after. And we are going to trust to God that the people who are elected to look after the other things that have to do with running this nation will do their job as well as we shall try to build the tanks!

EDITOR'S NOTE.—Following the above address, some 900 members of the Army Ordnance Association were guests of Mr. Keller on an inspection tour of the Detroit Tank Arsenal. The visitors were shown through the extensive establishment where medium tanks were actually on the assembly line and completed vehicles were undergoing tests on the track adjacent to the arsenal.

Graphic Production Control

The Use of Visual Guides in Armament Manufacture

James D. Mooney*

THE sheer magnitude of the arms program often suggests to the technical mind, as well as in the popular concept, the employment of "mass-production methods" as the surest means of effecting timely delivery of the vast quantities of essential weapons, armaments, and supplies. This emphasis on mass-production methods is, in many instances, not justified by the facts and conditions of actual production of armament items. Mass production is not a universal solution for all manufacturing problems but calls for a well-defined set of conditions and requirements if its potential advantages are to be fully realized.

It will be useful, as a preliminary to the subject of this paper, to discuss briefly the nature and characteristics of mass production as it is known in the industries in which it is most widely applied. Among these, undoubtedly the best known example is the automobile industry.

As its name implies, the first requirement of mass production is a "mass" of identical parts or units to be produced. Many defense items proposed for "mass production" run afoul of this first requirement. Even though total quantities are in some cases quite impressive, closer examination reveals modifications and variations which eliminate true volume-production possibilities from important sections of the entire unit. Further, in some elements of the arms program, such as pursuit-type aircraft, unexpected changes in design are interposed, dictated by the constantly increasing severity of performance requirements in actual combat service. Such revisions in design cut short the flow of production until the necessary changes can be made in the drawings, templates, fixtures, and dies.

Another characteristic of mass production in its most effective form is a thorough-going collaboration between the design-engineering staff and the manufacturing or production engineers. Manufacturing executives, familiar with the characteristics and capacities of the equipment on which the various parts will be produced, must have opportunity and time to suggest modifications in form and material which will bring each piece and subassembly within the most effective range of the available production machinery and equipment.

This requirement implies the fulfillment of another basic factor in the employment of mass-production methods: There must be an adequate preliminary period for preparation and make-ready, during which design is crystallized, material specifications established, plant and equipment made available and arranged for most effective use, raw-material sources established, schedules arranged, templates, dies, and tooling fixtures designed and made, and manufacturing and assembly operations routed and timed. Only if these preparatory and coördinative measures are adequately provided for in terms of time and man power can the entire mechanism function as an efficient, coördinated unit.

It is important to note that, in many cases, deliveries of finished units in small quantities can begin at an earlier date, if built by less highly mechanized methods, through the utilization of the long "make-ready" period needed for true mass production. Once under way, however, the well-integrated and coördinated mass-production set-up can attain rates of output which would be impossible by any other manufacturing process.

IT is typical of any highly integrated organization or process that it is more vulnerable to defects in coördination and timing than a lower-geared, more elementary set-up. The relative damage from failures and interruptions, in terms of output, is also usually higher in the more precisely timed production mechanisms. In consequence, control principles and methods are of far greater importance in mass production than in a less highly mechanized production structure. Machinery must be effectively suited to its specific function and located to maintain the most direct flow of production. Processes must be timed and equipment set up in multiple units, where necessary, so that the capacity of all parts of the productive mechanism will be uniform. Materials must be available at the point needed, on time and in proper quantity. Inspection must be provided at all critical junction points in the processing to insure complete interchangeability and thus avoid subsequent delays due to incorrect dimensions or specifications. Shortages of material, machine capacity, and man power must be foreseen and corrected with the minimum of delay.

Control and coördination so broad in scope and so detailed in character call for a widespread knowledge, at all levels of the organization, of the time and production objectives and of the performance against these objectives. For each department or subdivision of the organization, this information would be in terms of the parts, subassemblies, or complete units which are the responsibility of that department.

In summary, therefore, "mass production" may be defined as the most efficient application of organization, materials, man power, and machinery for the production of identical parts or units, maintaining the desired relationship between investment, unit cost, and time factors, and characterized by the following:

(1) A degree of mechanization, tooling, and general mass-production provisions proportionate to the probable volume to be produced without major or critical changes; (2) Sufficient flexibility and latitude in tooling and mechanization to accommodate probable or anticipated design changes within agreed limits as to character, location, and extent; (3) Stabilized design and specifications in keeping with the volume provisions mentioned above; (4) An adequate period of time for preparation and make-ready; (5) Close collaboration between the design staff and the production engineers at all stages; (6) Complete and accurate drawings and specifications; (7) Layout of plant and location of machinery and equipment to insure progressive flow of the work in process; (8) Special-purpose machinery wherever justified;

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This is an address delivered at the Ordnance Production Session of the Twenty-Second Annual Meeting, Army Ordnance Association, October 9, 1941, the Book-Cadillac Hotel, Detroit, Mich.

All values, dates, and quantities in the text and charts in this article are fictitious and are used merely to illustrate graphic control methods.

(9) Mechanical material-handling equipment wherever justified; (10) Adequate process and final inspection at all critical points; (11) Scheduled supply of materials to points of use; (12) Thorough "indoctrination" of all levels of the organization; (13) Control of every vital step. Without such control, few of the potentialities of mass production can be fully capitalized. Graphic methods provide the highest development of the principles of control. Years of experience show that graphic controls make possible a broad understanding leading to well-founded decisions and accurate appraisal of the future. Graphic controls bring together man power, machinery, and materials at the proper time and place and in scheduled quantities.

This paper deals with the final point in the foregoing list—the question of graphic control—specifically in its application to the arms program. This is a matter of the highest importance, not only because it is an essential accompaniment to any organized mass-production program, but because it has far wider implications which make the principles of graphic control of paramount importance to our national leadership in dealing with the defense program as a whole.

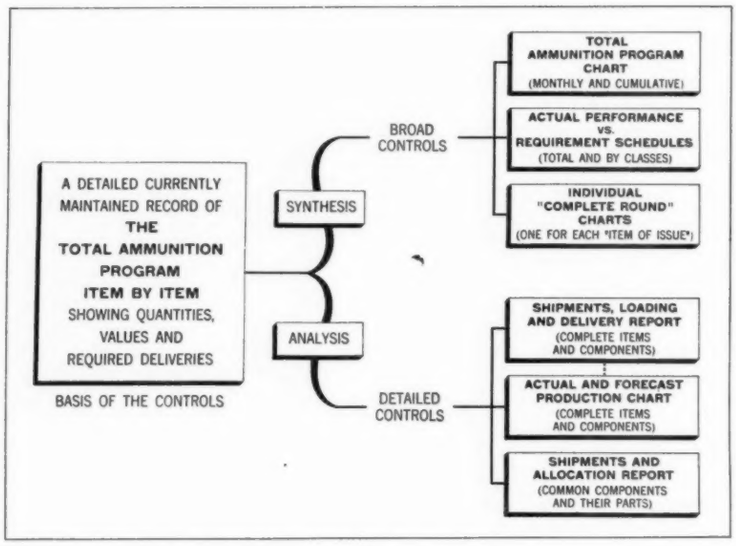

A DETAILED CURRENTLY MAINTAINED RECORD OF THE TOTAL AMMUNITION PROGRAM ITEM BY ITEM SHOWING QUANTITIES, VALUES AND REQUIRED DELIVERIES
BASIS OF THE CONTROLS
SYNTHESIS
ANALYSIS
BROAD CONTROLS
DETAILED CONTROLS
TOTAL AMMUNITION PROGRAM CHART (MONTHLY AND CUMULATIVE)
ACTUAL PERFORMANCE VS. REQUIREMENT SCHEDULES (TOTAL AND BY CLASSES)
INDIVIDUAL "COMPLETE ROUND" CHARTS (ONE FOR EACH "ITEM OF ISSUE")
SHIPMENTS, LOADING AND DELIVERY REPORT (COMPLETE ITEMS AND COMPONENTS)
ACTUAL AND FORECAST PRODUCTION CHART (COMPLETE ITEMS AND COMPONENTS)
SHIPMENTS AND ALLOCATION REPORT (COMMON COMPONENTS AND THEIR PARTS)

FIG. 1. AMMUNITION PRODUCTION CONTROLS

UNDOUBTEDLY the strongest impression which the arms program makes upon the technician and production engineer is the multitude and variety of engineering, design, and manufacturing problems involved in the production of the aircraft, ships, tanks, guns, ammunition, and other items which comprise the endless list. Less obvious, but even more significant, is the fact that most of these problems lie in an area largely outside the normal engineering and production experience and equipment of the industrial plants which have undertaken these defense jobs.

This does not apply in any decisive degree to the vast textile, clothing, and food requirements of the defense program. It does apply in some measure to defense items related to normal industrial products, such as military cars and trucks, merchant shipbuilding, certain types of aircraft, instruments and accessories, and certain construction jobs. In these areas, the crux of the production problem, aside from the mastery of necessary military modifications, lies in the great magnitude of the assignments and the shortness of the available time.

The third class, by far the highest in importance and urgency, involves the production of vast quantities of technically complex defense items which differ almost entirely from the normal products of industry. These differences extend from the raw materials, with their special metallurgical requirements, to special heat-treatment techniques and intricate machining and finishing to closest limits. Almost every step in these special processes requires facilities and equipment which are seldom found in any normal peace-time industrial plant. Management and technical staffs must carry the responsibility for the analysis of these special problems and their assimilation into the industrial structure of the country. Nothing could be more obvious than that normal routine methods and rule-of-thumb planning and control will prove inadequate for this job.

Almost every one engaged in a technical manufacturing enterprise would admit that in his own business, particularly if it has been running along smoothly for a period of years, most problems of supply, engineering, and production have had a way of getting themselves solved through sheer familiarity with the conditions and limitations on the part of all concerned. In the unfamiliar areas of the defense program, however, all this is vastly changed. In place of the old, well-explored problems, a whole new school of questions arises, in the solution of which normal business and manufacturing experience of many years can provide only a general sense or guide, rather than the complete answer.

AMONG the sternest lessons of national experience, taught many times at incalculable cost in modern warfare, is the validity of a simple principle. This principle holds that as the magnitude and complexity of operations are increased, the need for coördination and control is increased in geometric proportion.

In facing the huge arms program, those charged with the responsibility for leadership, policy, and major decisions come face to face with the vital necessity for a closely coordinated control mechanism whose scope, accuracy, and speed will be proportionate to the size and complexity of the job to be done. To cover the problem as a whole, such coordinating and controlling influence must extend to the outer limits of the huge defense effort. Strong forces are at work in many quarters to push forward with the execution of the defense task. The possibilities of intensified, broadened and reënforced effort are being exploited to a high degree.

Less fully exploited, however, is the field of greatest potential advantage, which embraces the direction, coördination and control of effort and the elimination of waste motion and duplication.

The arms-production machinery can be brought to its most effective pitch only by providing the necessary cohesive and coördinating forces and by establishing a prompt and effective means for measuring results and for applying corrective action. A broad-gauge graphic control mechanism, covering the major aspects of the entire arms program, would provide our national leadership a means for insuring: (1) Clear definition and full understanding of objectives

and time requirements; (2) Thorough indoctrination of aims and objectives; (3) Fully integrated and coördinated information; (4) Accurate forecasting of future performance; (5) Analysis of weak spots, current and impending; (6) Corrective action.

The principles of graphic control are simple and few, but its forms and uses are as varied as the problems and conditions to which graphic methods are applied. The value of graphic presentation of the essential elements of a problem or situation rests on a firm base of philosophy and psychology. A simple road map or sketch, compared with the most elaborate verbal directions, provides a common illustration of this point. "A picture is worth a thousand words," "The eye is the pilot of the mind"—these much-quoted expressions of the graphic principle are more than ever significant today as we face defense problems of surpassing magnitude and complexity.

Successful execution of the arms program calls for decisions and action in a field which, industrially, encompasses the entire nation. The effects and influences of these decisions extend throughout the entire world. These broad decisions must rest on a foundation of facts—comprehensive, accurate, and current facts—readily available and clearly presented.

Experience in many fields supports the view that only through graphic control methods at all levels of the defense organization can the development of the complex defense effort be presented and kept available for review and action. An effective graphic control mechanism offers the following advantages:

Time saving.—Properly designed graphic controls can be read and interpreted at a glance. They reveal the essential factors and focus attention on the weak spots. They can be presented to a group and discussed by them and thus insure immediate understanding and complete unity of action. All but vital data are eliminated, and no time is lost in examining and discarding information of secondary importance.

Coördination.—Graphic control methods provide the most effective means of controlling the various sections of a defense problem, be it the quantity production of a machine gun or the coördination of broad phases of the over-all defense effort. Graphic methods throw into clear relief the need for intensified pressure at one point and the possibilities of relaxation, to compensate, at other points. A unified graphic control serves as a mental and psychological "rallying point" for all individuals and groups engaged in the joint effort and thereby provides a clear universal understanding of objectives. In this way, it contributes substantially to the "indoctrination" of the entire organization.

Control.—The key function of a graphic master control is, obviously, to provide the basis for control. Typical of every phase of an effective graphic control is a running comparison between actual and forecast performance with the scheduled requirements and time objectives. These running comparisons, together with any improvements or retrogressions, are brought into sharp focus by graphical presentation. Thus there is provided an index for the application of intensified effort. Carried down into all levels of defense production, this "principle of comparison" is continually split into smaller elements, with the result that proper action on each individual item is sharply defined by a process which is automatic in action and comprehensive in scope.

It has been my privilege to observe closely some phases of the control problem, viewed from the standpoint of the armed forces. In particular, the Ammunition Division of the Ordnance Department in Washington has been building up an excellent set of production controls for ammunition, and I have been fortunate enough to have held a "ringside seat" during the development of these graphic control methods and reports.

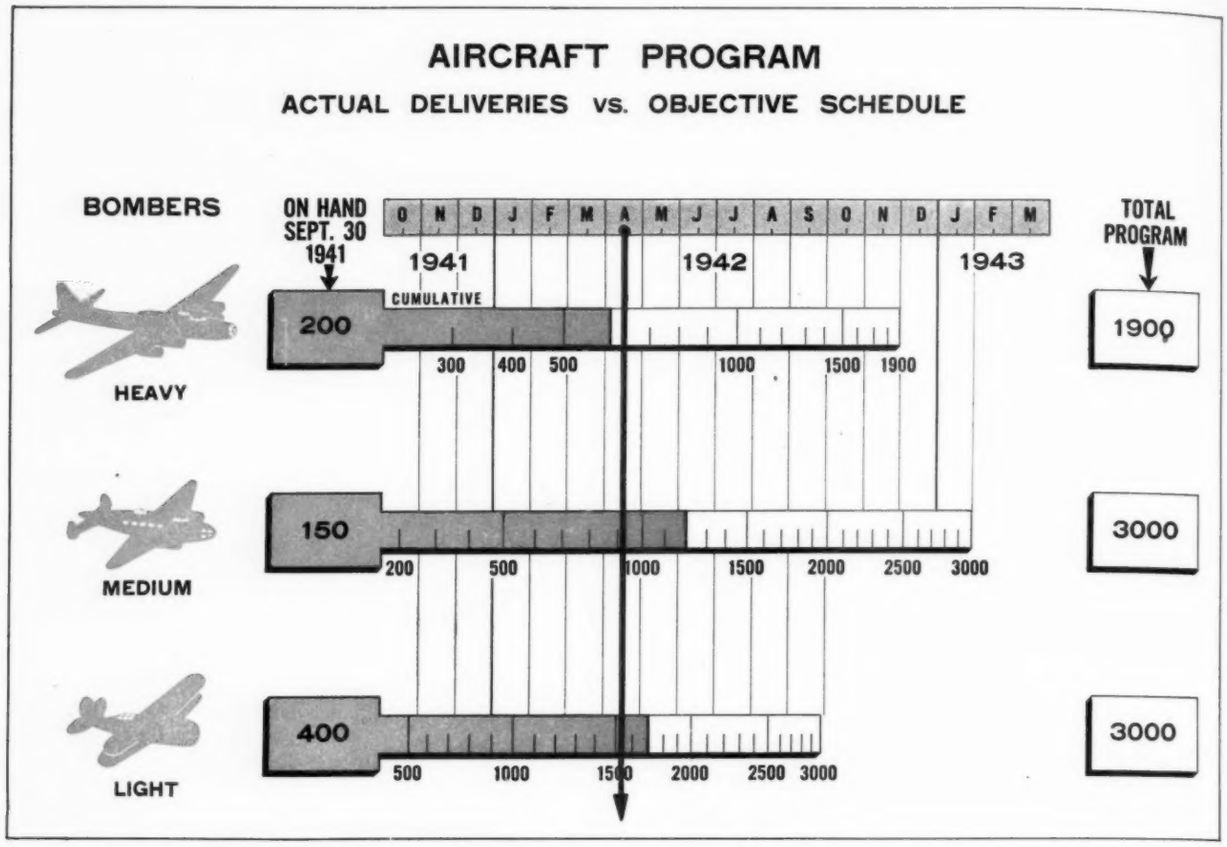
THIS work was started under the direction of Col. F. H. Miles, Jr., then chief of the Ammunition Division, with the support and coöperation of Maj. Gen. C. T. Harris, Jr., chief of the Industrial Service. It is being carried forward to broader fields and to an increased level of effectiveness by Col. H. H. Zornig, now chief of the Ammunition Division, and his organization, among whom Lieut. Col. M. H. Davis, Lieut. Col. D. C. Hall, Capt. J. A. Mathews, Lieut. A. L. Fabens, Dr. R. Ilsley, and W. V. A. Kemp have made important contributions. A business associate of mine, W. B. Wachtler, has acted as consultant in the development of these controls.

I believe it would be useful to discuss these ammunition controls in some detail, not alone for their intrinsic interest but as a mental stepping-stone to the concept of a broader control, following the same principle but covering the entire field of the arms program and expressed in broader terms of maximum usefulness to those responsible for the forward movement of the entire defense effort. To my mind, such an over-all visualization of the problem and the progress being made in its various phases would be the largest immediately practicable contribution to the effective execution of our national policies.

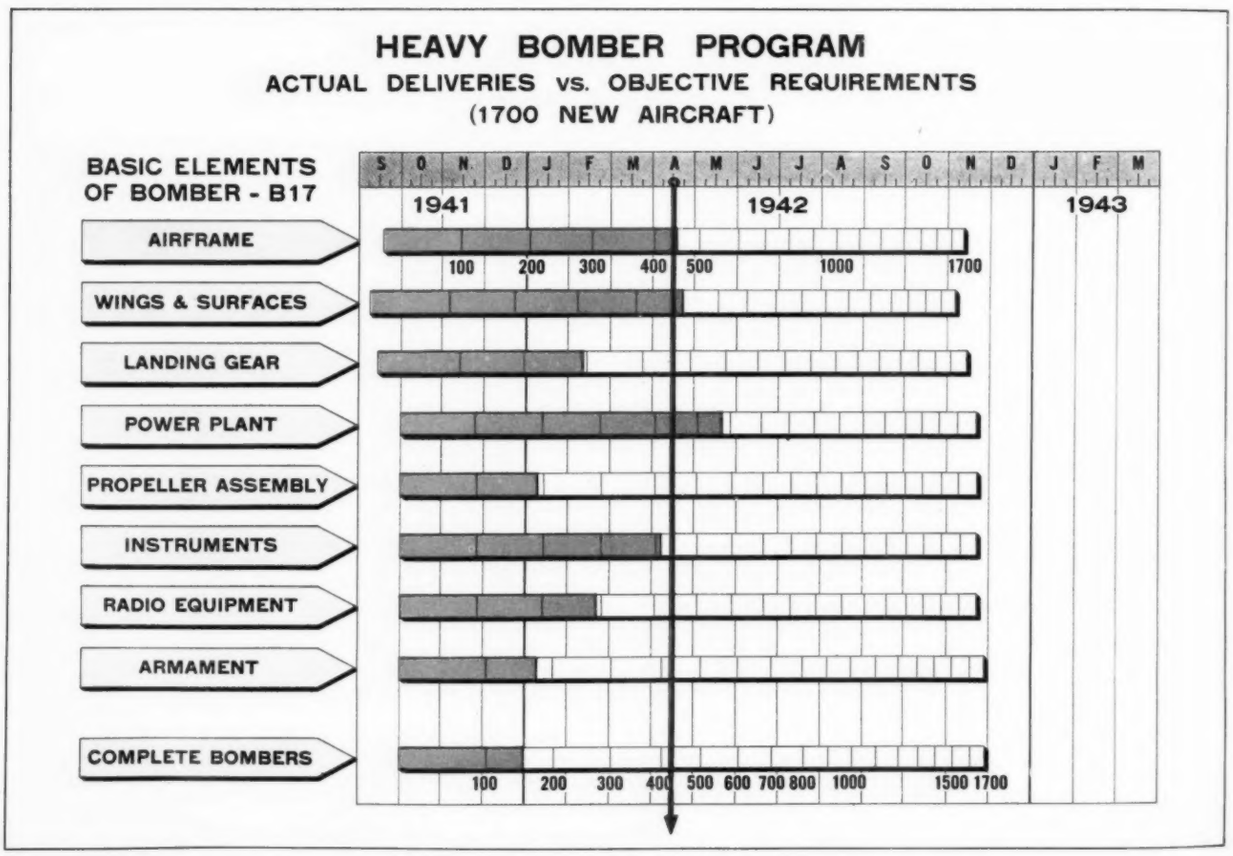
The basis of these controls is the ammunition program, which is a constantly expanding total summary of the ammunition items and materials authorized for procurement, reflecting the requirements of the Army, some naval ammunition, aircraft bombs, cannon ammunition and other aircraft items, and certain Defense Aid items. The program currently includes over two hundred individual items of issue, some to be provided in quantities of hundreds, and others in tens of millions. Each of these items consists of from two to ten major components, many of which are interchangeable between the various "complete rounds." Some components are made of from two to six "parts," many of which are produced by a dozen or more different manufacturers.

The network of procurement and production has extremely wide ramifications which, through the agency of the Ordnance District offices, extend into almost every field of American industry and involve hundreds of companies as contractors and subcontractors. The provision of the necessary powder, explosives, and their basic chemical constituents, as well as the loading and final assembly of the complete ammunition items, is largely the task of Government-owned plants, operated by private management. Although substantial producers of some types of ammunition, existing Government arsenals come into the picture principally as "pilot" plants, where manufacturing processes are developed for subsequent transfer to private manufacturers to whom contracts have been awarded for the item in question.

As pictured in the accompanying chart, Fig. 1, the development of the control moves in two directions from the basic ammunition program. It moves first toward a classification and synthesis of the many individual items to form groups of related items and, finally, an over-all consolidated picture. It moves also toward the analysis or breakdown of complete items into their components and the components into their



In Fig. 2, above, and Fig. 3, below, the red arrow indicates the current date (here assumed to be April 15th); the green shading shows total actual deliveries to that date. White space to left of arrow indicates items behind schedule.



parts. Such analysis provides the only means of measuring and controlling production and procurement in a practical and effective sense. These diverging paths lead to six major types of controls, whose general character is indicated in the six rectangles at the right of this chart.

The control chart Fig. 4 gives the picture of the over-all program, and corresponds to the top rectangle at the right in Fig. 1. In this consolidated control chart, the ammunition program as a whole is expressed in the common denominator of dollar values. This permits comparison with appropriations and authorizations.

If the various items of issue were delivered to Field Service in accordance with the "objective-requirements schedule," the cumulative value of such deliveries, at current average prices, would grow as indicated by the heavy broken line in Fig. 4. (All values and quantities shown in this and all following charts are fictitious.)

The lighter solid line portrays the cumulative value of deliveries if these were made in accordance with the "plans of production" as specified in the contracts for procurement of component parts and materials. Actual deliveries, converted to dollars by the use of the same current average values, are shown by the heavy black line. Each month a forecast is made of actual deliveries over the next four months, and the corresponding cumulative values are indicated by the small circles. As new authorizations for procurement are added, the "objective-requirements" line is modified and extended accordingly. Similarly, the "plan-of-production" line is revised and extended as called for by modifications in the production schedules of contracts outstanding.

Based on the same data as Fig. 4, a parallel chart is also maintained in which the objective and actual deliveries and the forecasts are shown for each month individually instead of cumulatively. Current photostats of both charts are included in the ammunition control books held by department heads concerned with ammunition production.

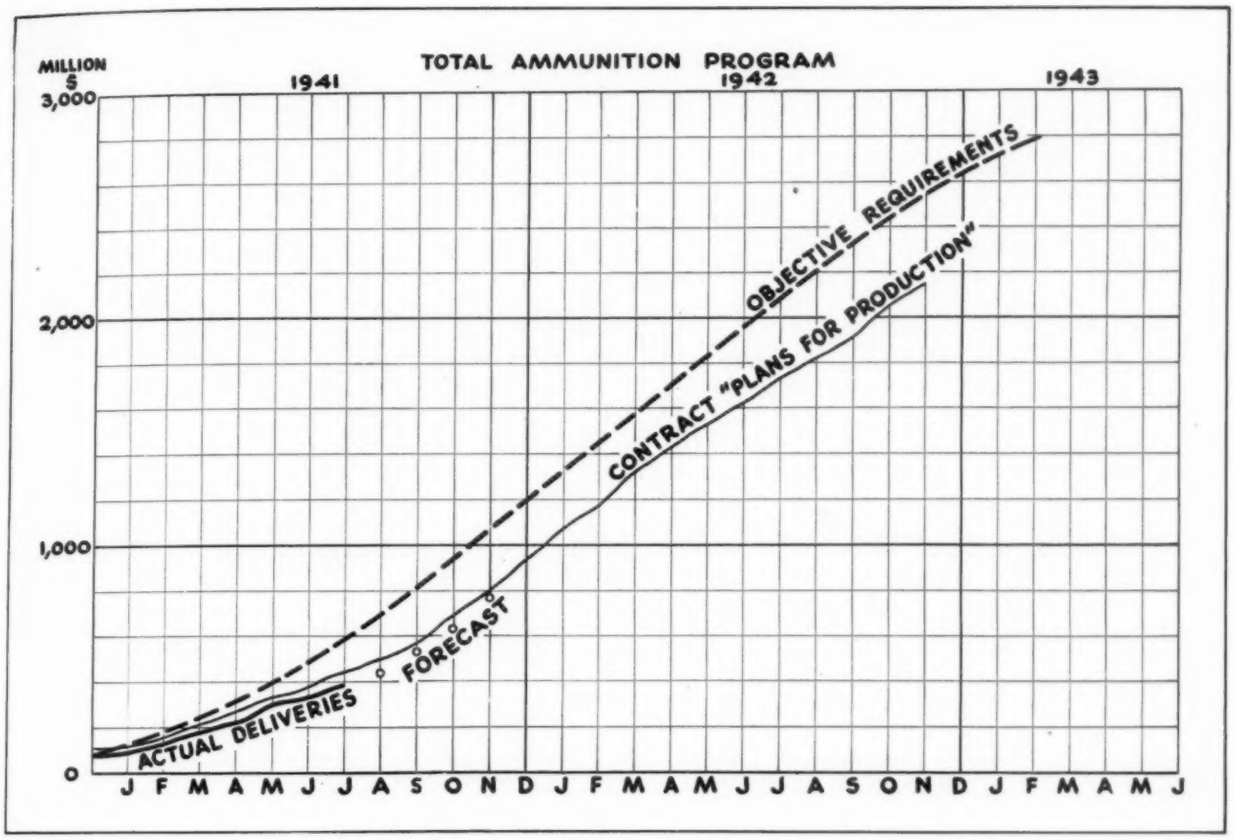


FIG. 4. THE TOTAL AMMUNITION PROGRAM IN DOLLAR VALUES

(The charts indicated on the third rectangle from the top of Fig. 1, "individual complete-round charts," are in the same form and present the same information as the "total-program chart," Fig. 4, except that there is one chart for each complete item or round of ammunition, and the quantities are expressed in units of rounds instead of dollars.)

FOR practical control purposes, the over-all data as presented in Fig. 4 must be supplemented by more specific information. The first step toward a more detailed picture is shown in Fig. 6. This control chart is a current graphic record of performance versus objective schedules for the principal "classes" of ammunition.

The numerous complete rounds or "items of issue" have been grouped for convenience of control into fourteen principal classes (only three of which are shown here)—the shells grouped according to their caliber, followed by mines, grenades, bombs, pyrotechnics, propelling charges, etc. For each class of ammunition, the control chart shows the total number of rounds authorized for procurement, the objective delivery schedules, and the actual delivery performance as of any given date.

Each group or class of ammunition is represented on the chart by a bar extending from the beginning of 1941 to the

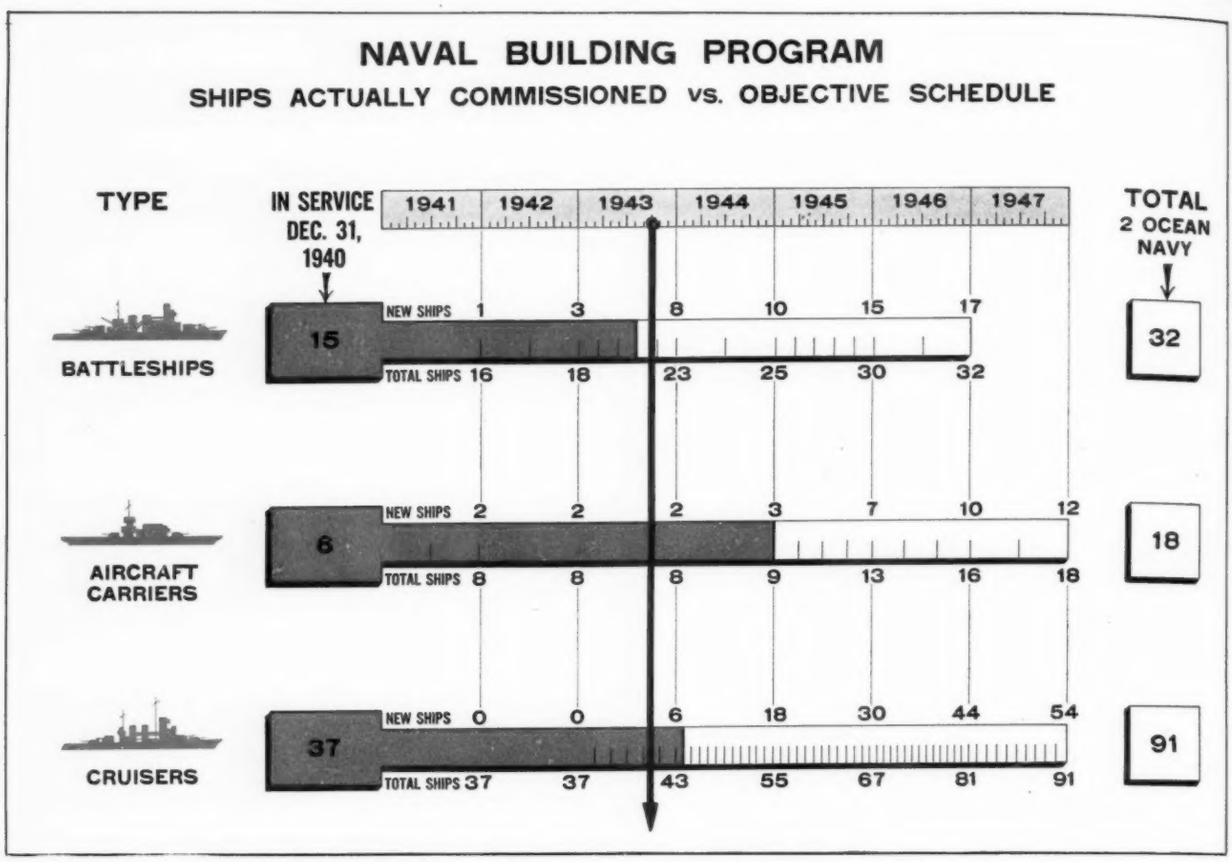
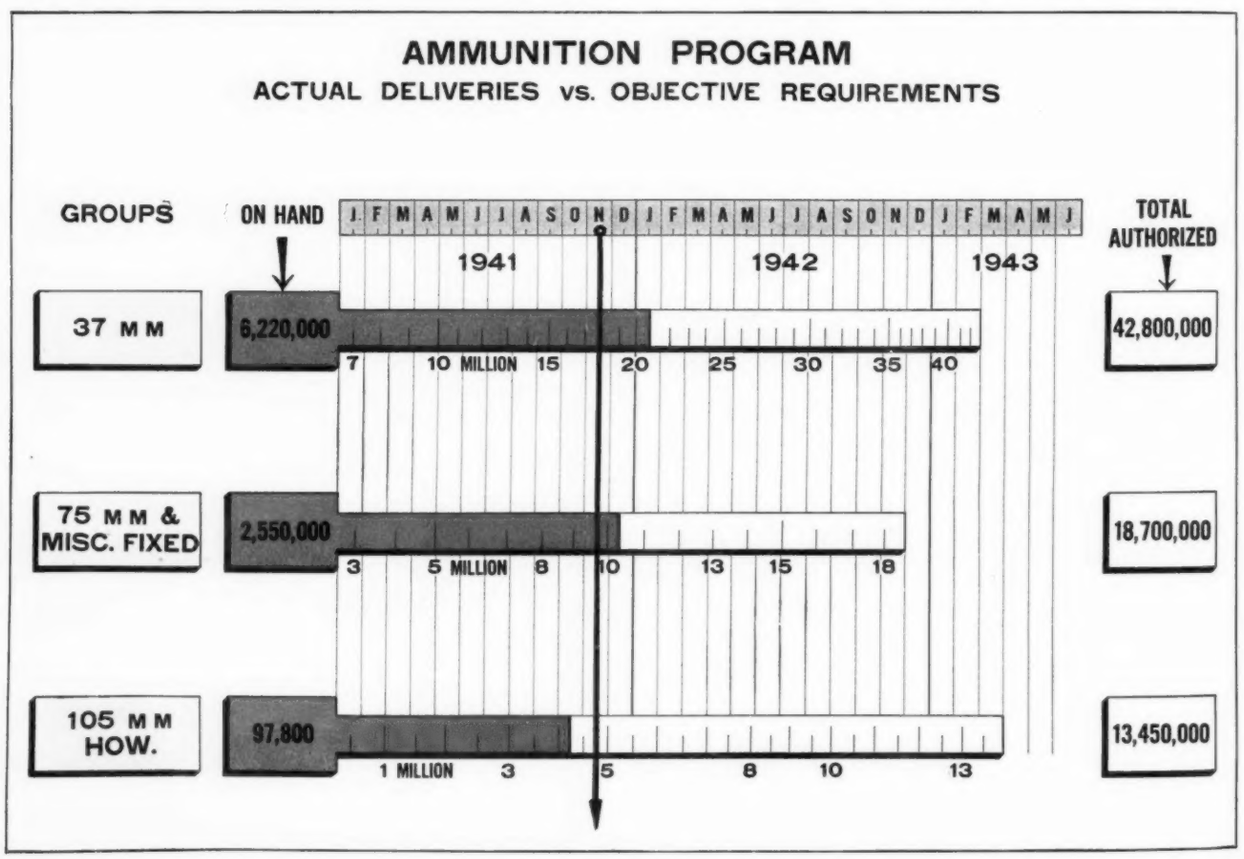

NAVAL BUILDING PROGRAM
SHIPS ACTUALLY COMMISSIONED vs. OBJECTIVE SCHEDULE
TYPE
IN SERVICE DEC. 31, 1940
1941 1942 1943 1944 1945 1946 1947
TOTAL 2 OCEAN NAVY
BATTLESHIPS
15
NEW SHIPS 1 3 8 10 15 17
TOTAL SHIPS 16 18 23 25 30 32
32
AIRCRAFT CARRIERS
6
NEW SHIPS 2 2 2 3 7 10 12
TOTAL SHIPS 8 8 8 9 13 16 18
18
CRUISERS
37
NEW SHIPS 0 0 6 18 30 44 54
TOTAL SHIPS 37 37 43 55 67 81 91
91

Fig. 5, above, shows ships actually commissioned versus their objective schedules in the present naval building program. Fig. 6, below, indicates actual deliveries versus the objective requirements, by groups of ammunition.


AMMUNITION PROGRAM
ACTUAL DELIVERIES vs. OBJECTIVE REQUIREMENTS
GROUPS
ON HAND
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J
1941 1942 1943
TOTAL AUTHORIZED
37 MM
6,220,000
7 10 MILLION 15 20 25 30 35 40
42,800,000
75 MM & MISC. FIXED
2,550,000
3 5 MILLION 8 10 13 15 18
18,700,000
105 MM HOW.
97,800
1 MILLION 3 5 8 10 13
13,450,000

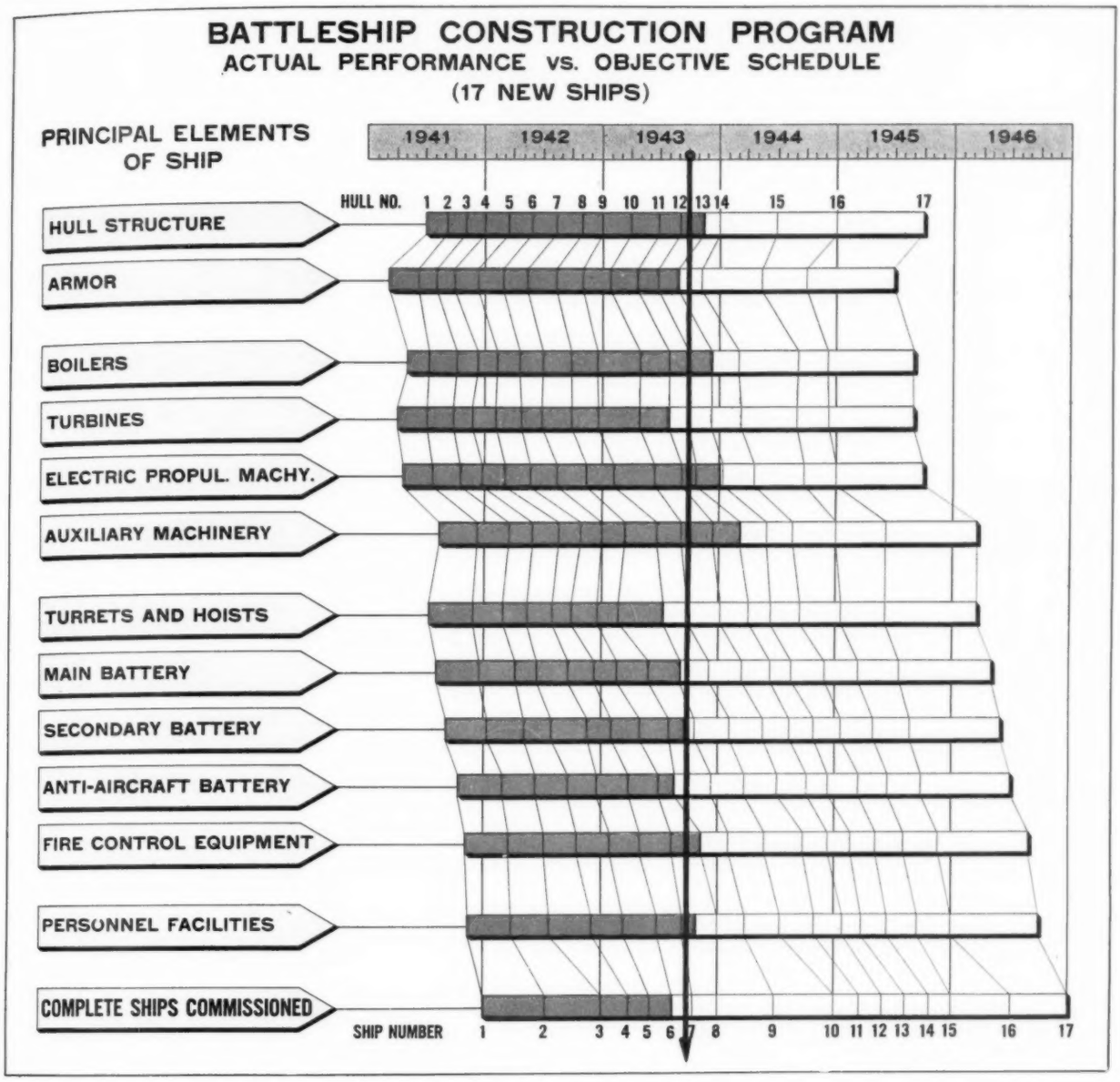


FIG. 7. BATTLESHIP CONSTRUCTION PROGRAM

date when the total quantities authorized are due for completion in accordance with the "objective-requirements" schedule.

Intermediate delivery requirements, in terms of complete rounds or items are indicated along the length of the bars at the appropriate dates. These graduations are not uniform, but fall closer together in periods of maximum production. A weighted cord as shown represents the current date (November 15, 1941, in this case) and indicates the required cumulative deliveries of each class of ammunition as of that date if the time objectives are to be attained.

As actual deliveries are reported, the bar is shaded to the appropriate point as indicated in green. Any white space to the left of the current date line indicates a shortage, and any shading to the right of the current date indicates that deliveries in that class are ahead of the required schedule. Similar charts are maintained for each individual "item of issue" within the respective classes, in each of which the same methods and principles apply.

Photostats of this entire family of charts are maintained currently in all copies of the ammunition control books, which are kept for reference in all offices concerned with ammunition production and procurement.

All the foregoing controls have dealt with complete ammunition items as these are issued to the field forces. Each complete item, however, with a few exceptions, such as flares and pyrotechnic signals, consists of from two or three to ten components which are extremely varied in character and which must be procured from manufacturers in widely different industries.

For example, a 75-mm. high-explosive shell has seven principal components, not including the packing and shipping materials. The shell body is of forged and machined steel, fitted with a copper rotating band. The fuze is an intricate mechanism of steel, aluminum, and brass. It requires machine work, careful assembly, and minute inspection of numerous small parts, some of which subsequently must be loaded with a special detonating material.

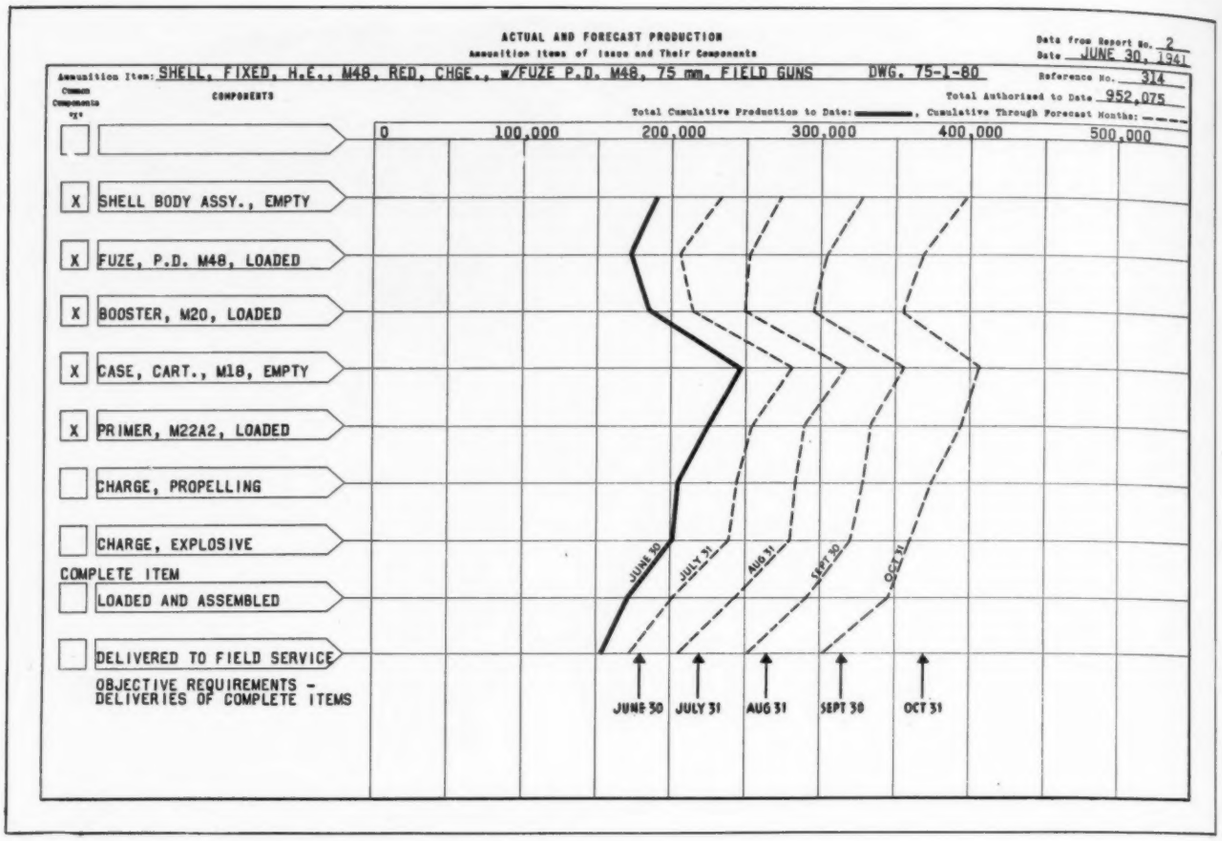


FIG. 8. ACTUAL AND FORECAST PRODUCTION OF AMMUNITION COMPONENTS

The "booster" calls for metal drawing, stamping, and machining operations and, when complete, this part also must be loaded with explosive. The cartridge case is of drawn brass and is fitted with a separate primer, also of brass, which must be loaded with a detonating material. When all these metal parts are assembled at the loading plant, the hollow shell body is filled with a high explosive, and a carefully measured quantity of smokeless powder is placed in the cartridge case as a propelling charge.

It is obvious that only finished rounds of ammunition are of any use to the combat forces and, further, that a shortage of any one component renders all the rest valueless until the missing item is provided. One of the most important functions of control in the production of ammunition is, therefore, to bring all components of a given round in "company front" to the loading and assembly plant at the scheduled time and in the specified quantity.

A MEANS of exercising and evaluating the control of this key function is provided by a statistical form dealing with the various elements or components of a given complete round or ammunition item. A separate sheet is prepared monthly for each item of issue, and the 200-odd sheets are bound in a loose-leaf cover for convenience of reference.

This report shows the total quantities of the various components that were shipped from contractors' plants or Government arsenals into the hands of the Ammunition Division during the preceding month, as well as the cumulative shipments to the date of the report. It shows also the best estimate or forecast of what such shipments will be for each of the next four months. These monthly figures also are expressed in terms of the expected cumulative shipments of components as of the end of each month. Obviously, the component with the lowest cumulative shipment figure as of any given date is or will become the limiting factor in the total loading and assembly of complete rounds as of that date.

The report shows also the monthly and cumulative quantities of complete items loaded and assembled, including the past month, cumulative to date, and for the four forecast months. The delivery of complete items to Field Service is shown on the same basis. For purposes of comparison and evaluation, the objective delivery schedule, as well as the forecast made a month earlier, is shown adjacent to the latest complete-round delivery data.

Some components, such as fuzes, boosters, and cartridge cases, are used in several different complete rounds and are known as "common components." The shipment and availability figures for common components as shown on any given report sheet refer only to the quantities specifically allocated to the complete round of ammunition covered by that report. In some cases, a complete item of issue is not a complete piece of service ammunition. A loaded bomb body, for example, is an item of issue, but to be of use in the field it must be associated with a fin, an arming wire, a nose fuze, and a tail fuze, each of which in its own right is an "item of issue." "Common components" and "associated items of issue" are identified as such in the statistical form described above. Fig. 8 is a graphic control form which portrays visually the situation covered statistically in the foregoing report. It is evident from this graph that up to June 30th (all figures are fictitious) the fuze has been the limiting

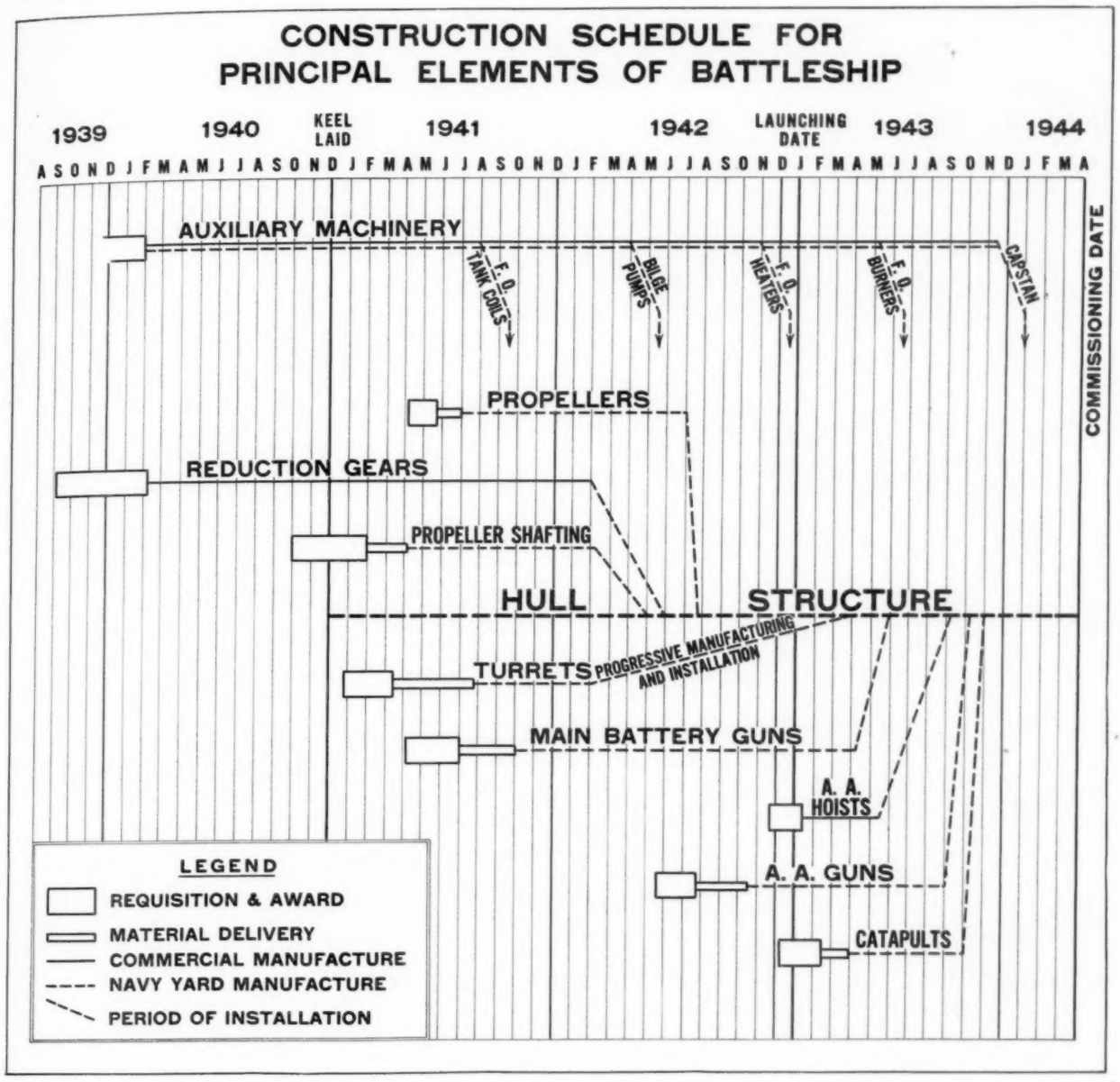


FIG. 9. OBJECTIVE SCHEDULE OF BATTLESHIP CONSTRUCTION

component and that this condition is expected to prevail through July. In August, however, the fuze has gained ground, while the cumulative production of booster M20 has fallen, so that this now represents the limiting factor. This situation is expected to continue throughout the forecast period ending October 31st.

The arrows along the bottom line indicate the quantities of complete rounds called for by the objective-requirements schedule through the respective months. It is evident from a comparison of the forecast with these objective points that in spite of growing production as forecast, this round will fall increasingly behind its time objective. At the end of June, the actual deficit was 28,200 rounds, whereas by October 31st the shortage as forecast would be 69,200 rounds.

AS already mentioned, many components of complete rounds of ammunition are common to several rounds. Aside from obvious examples such as boosters, fuzes, and primers, a shell body might be used in three or four different chemical shells, and a cartridge case might apply to several shells of the same type and caliber.

This introduces the question of allocating deliveries of such common components to the various rounds. Decisions as to such allocations depend on several factors, among which the principal ones are:

(1) The order of preference or priority of the complete rounds, as established by higher authority from strategic considerations.

(2) The presence or absence of all other components of a round. It would, for example, be useless to allocate a substantial portion of the deliveries of a shell body in a given month to a round which cannot be completed because of the lack of the specified fuze, when the same shell bodies are badly needed for some other shell for which all components are available.

(3) Loading and assembly capacity. If the entire capacity

of a loading line is taken up for a given period by a round for which all components are available, it would not be advantageous to allocate more fuzes, for example, to this round if some other line, loading a different round, faced the necessity of shutting down due to a short supply of the same fuze.

A step in the control of this phase of the problem is provided by the report indicated in the lowest of the six rectangles in Fig. 1. This report deals with the ordering, shipment, loading, and delivery of components and parts of components instead of complete rounds and complete components. In addition, it lists the several complete rounds or items of issue of which the component in question forms a part, and indicates the actual and forecast allocation or distribution of this component among the complete rounds.

The Ammunition Division must concern itself not only with the procurement, production, and delivery of the authorized quantity of complete ammunition items according to the required schedule, but must also face the problem of building up productive capacity for all types of ammunition to specified monthly rates for each item within specified periods of time, ultimately attaining the full estimated war-expenditure rate. Controls have been established to portray the progress toward these objective capacities and dates, taking into consideration not only the actual capacity attained and projected, but also the equivalent "full-normal" capacity if all contractors were on a 120-hour-per-week work schedule.

THE foregoing somewhat detailed description of the ammunition controls illustrates the scope and versatility of graphic methods of control and presentation, from the broadest over-all view of the entire program to the delivery of the parts of a component and the allocation of the component to a complete round of ammunition.

The principles involved in these graphic controls are applicable—indeed, are being applied with great effectiveness—in many branches of the Army and Navy procurement and production departments today. The extension of these applications into fields not now covered, and the unification and coördination of the isolated, individual control mechanisms into a fully integrated master graphic control for the entire arms program would unquestionably be one of the longest forward steps that could be taken at this time toward the fulfillment of our national-defense objectives.

Other applications of the principles developed and discussed are suggested by the other charts shown. Fig. 2, for example, is a diagrammatic sketch of a control board which would serve as an over-all check on deliveries of the complete aircraft which constitute the bomber program. The three types of bombers—heavy, medium, and light—are considered as separate groups, and it will be noted that the example assumes a total program requirement of 1,900 heavy bombers to be completed November 30, 1942.

There were, by assumption, 200 complete as of September 30, 1941, leaving 1,700 additional to be delivered in the intervening period. The schedule of required deliveries, in hundreds, is indicated by the graduations on the bar. The status of the deliveries on the assumed "current date" of April 15, 1942, is that a total of 600 have been delivered, as shown by the end of the green shading. However, the schedule, as marked by the red cord against the graduations, would call for 630. Therefore, in the example, the heavy bombers are thirty complete aircraft behind schedule on the assumed "current date" in question.

In Fig. 3, the required 1,700 new heavy bombers are segregated from the rest of the bomber program, and the principal elements of the B-17, the model in question, are scheduled and controlled in the same manner as was done with the complete aircraft in Fig. 2. This process of subdivision and refinement can be carried to any desired degree of detail, depending upon the type of control desired.

Fig. 7 shows the same type of control chart as Fig. 3 applied to the principal elements of the seventeen new battleships called for by the over-all naval program covered by the control chart in Fig. 5.

A graphic representation of the objective schedule in the construction of a battleship is shown in Fig. 9. It illustrates further the flexibility of graphic methods and the effectiveness with which they can be applied to problems of widely different characteristics and conditions. This chart portrays the successive time elements required, from requisitioning the major elements of a battleship to the completion of construction and installation and, finally, the commissioning of the ship.

The long advance periods necessary for the outside manufacture of gears, shafting, and other heavy equipment, starting long before the keel is laid, stand out clearly in the chart. These in turn are preceded by even longer periods of preparation for design and engineering.

For operating control purposes, the appropriate sections and divisions of the Navy Department maintain coördinated construction schedules in far greater detail than in Fig. 9, which represents a "master-control" abstract of the major steps in the complex construction process.

AS the business men and industrialists of America size up these unfamiliar technical, manufacturing, and management problems which constitute the production side of the arms program, it comes as a shock to many to realize that the country is looking to industry for a prompt and effective solution of these problems. Indeed, if industry does not solve the problems and deliver the goods, the arms program never will be fulfilled.

Many of the jobs that must be done are remote, in their character and solution, from the normal activities and problems of the companies which have taken them on. The urgency for prompt and effective handling exceeds any conceivable pressure under normal operating conditions. It is clear that the tested and familiar production and control methods of peace time must give way to faster and more effective measures. Rule of thumb must be superseded by the studious approach and the open mind. Planning, charting, checking, and double checking will have to replace the quick decisions which were possible on more familiar ground.

This situation calls for an early and complete return to the basic methods with which every business had to approach the problems of its early, struggling years.

Among the most useful of the old tools, largely laid aside in recent years, are the graphic charts which proved themselves long ago as the best means of grasping, coördinating, and controlling new and complex problems such as those which constitute the arms program. Before the job really can be done, we shall have to "get it out where we can see it!"

EDITOR'S NOTE.—All values, dates, and quantities shown in the text and charts in this article are fictitious and are used merely to illustrate graphic control methods.

The Motor Industry and Defense

A Record of Mass-Production Machines and Methods

Alvan Macauley*

A WEEK ago, the leader of the Nazis, in a propaganda address to his people, belittled the defense work of other nations and, in effect, told them not to be frightened by reports of the billions of dollars involved in our programs. The factories of Detroit, and of the entire motor industry, would indicate today that he had good cause to try to bolster the courage of his misguided followers.

It is quite true that most of our published measures of defense work have been in dollars; and it is fitting they should be, for the dollars represent the man-hours and the machine-hours of free labor and free industry. It is quite true also that we do not have at our disposal the enslaved labor and the enslaved factories of a conquered continent, nor do we depend upon conscripted factories at home.

But it is the test of our productive program and the assurance of ultimate success that the mass-production industries of this nation never have been beaten by the competition of enslaved labor, no matter who is master. That has been true of our peace-time work; the facts of our program to date assure that it is becoming equally true of our war work.

The members of your organization know, better perhaps than any other group, how this nation refused to maintain a full-fledged munitions industry as a stand-by for war. But, through the liaison which your organization maintained in the years of peace and through the slender link of educational orders, there was established a mutual understanding and respect between the armed forces and industry, which are essential to coöperative action.

Today, we can recognize that this relationship between the military and naval services and the civilian producers became an asset of greater ultimate value than any stand-by war industry possibly could have been. For the new war that unfolded in Europe threw into the scrap pile such an enormous amount of planning and theory and made obsolete so much of the war equipment on hand or designed, that we were left face to face with the fact that as a nation we had just one sure shot in the production locker: The ability to organize for volume output on hundreds of brand-new tasks of the greatest complexity and on the tightest time schedule that any industry or nation anywhere ever contemplated at any time.

In war production, *volume* superiority is not enough without *quality* superiority. The Nazi competition demands that our equipment be capable of outdoing the best weapons already in use. To secure both volume and quality superiority in armament, which today is of great mechanical complexity, the industrial job had to be planned and organized from the ground up. It has been and will continue to be a time-consuming task.

Only if we understand the value and the ultimate return of this "time investment" in "make-ready" can we appraise the long stride which has been taken through the creation of facilities for volume output. Speaking for the automotive industry alone, here is a sketch of the defense program to date:

At the end of December 1940, the total military orders in the hands of the motor-vehicle companies from all sources, including foreign governments, stood at $915,000,000. There actually were more under way, for as you know, industry has not in this emergency stood entirely upon the formality of a contract. Yet the contracted total is accurate enough as a measure. Of the $915,000,000, more than a third represented variations of the industry's "bread-and-butter" line—cars, trucks, and their parts. The remaining two-thirds represented those products for which new capacity manufacturing facilities were desperately needed and had to be created.

The first tank program in the industry had been launched at that time—only four months before. The total for aircraft engines, equipment, and parts stood at $342,000,000. The present bomber program at year's end was very much in the exploration stage. For all kinds of guns and ammunition, the industry had been awarded contracts of slightly less than $105,000,000. Of the more than $3,500,000,000 worth of defense goods we are now engaged in manufacturing, orders for three-fourths were released to the industry within the first eight months of 1941.

The valuation of deliveries made by these companies since the turn of the year is a matter of estimate. On a dollar basis, it is safe to assert that deliveries in these months have exceeded two-thirds of the orders which existed at the end of December 1940. The exact valuation of deliveries, however, is second in importance to the fact that a flow of needed defense goods has been established. Facilities to produce them in great volume, which did not exist a year ago, have moved into operation, and they guarantee a sharply ascending rate of delivery.

This automotive industry is delivering, besides Quartermaster and Ordnance vehicles of all types, the following items: Aircraft engines and parts; aircraft equipment, including landing gear, propellers, instruments of great variety, and some initial deliveries of fuselage structure components; marine engines and other marine equipment; medium tanks, such as most of you have seen today, plus additional tank parts and engines; machine guns of varying calibers, in quantities which are well ahead of contract stipulations; assorted gun parts, including such items as mounts, coolers, fire-control equipment, recoil mechanisms, etc.; shell forgings and finished shells of varying calibers; cartridge cases, bomb fuzes, and other ammunition components; field kitchens, electric refrigerators, radios, tools, and dies.

To that list could be added a very sizable miscellany of items which do not bulk so large in terms of dollars or of units, but which are critically important and represent, like the others, the creation of productive capacity which did not exist before. This industry can report further that a number of facilities which were intended to be ready now—some of them ahead of schedule—have been retarded by the very wise choice of the authorities to step up basic capacity or to alter design to meet changed conditions.

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This is an address delivered at the Annual Dinner of the Twenty-Second Annual Meeting, Army Ordnance Association, October 9, 1941, the Book-Cadillac Hotel, Detroit, Mich.

Behind statistical listings are more important facts: Several of these production units have turned the corner for the first time—from handcraft and fine machine-shop production methods and volumes to true mass production on what we define as "multimatic" machines and methods. Others have developed sensational process short cuts without abandoning the flexibility of tooling demanded by the ever-present military necessity for changed specifications, increased power, etc.

That this industry has made good so far is the best guarantee in the world that the next phase of production requiring more engines, more guns, more tanks, more, in fact, of everything, will be piloted to a successful conclusion within the expectable time limits.

The "making good" to date also justified complete confidence in successful performance of the most dramatic and the largest of the pending jobs; namely, volume output of long-range and medium bomber fuselage structures. That work is well forward in those same arduous "make-ready" stages that necessarily are involved in every new assignment.

In saying that results to date guarantee future results, we must recognize that difficulties on the whole grow and do not diminish as the volume of defense work in this industry leaps ahead.

Future success will call for more and not less mutual understanding, respect, and collaboration between industry and labor, and between industry and Government. Just as the pressure for materials increases, so does the intensity of need for tools and facilities of all kinds. Fortunately for a defense program whose ultimate scope and size still is out of sight, the reserve powers of the motor industry were not drained in the process of putting into action the first groups of defense plants. *We have more to draw upon.*

The program so far assigned the motor industry totals somewhat more than $3,500,000,000, as I have said. By far the greatest part of this total at the moment, goes to aircraft products which represent 56 per cent of the total or, roughly, $1,960,000,000. The next most sizable portion of the total is for motor vehicles of various types, totaling 20 per cent. Principal ordnance items in the last available summaries are: tanks 4.2 per cent; guns and ammunition 12.6 per cent. These figures do not reflect expansion programs which are now in preparation, including large additional military tank orders. Marine power equipment constitutes another 6.5 per cent, and the remainder is made up of miscellaneous products.

When all this is said, there remains a major question: "Is the automobile industry being employed to its full ability in the present program?" As of today, the answer has to be an unqualified "No!" The potential capacity of the industry for defense is far beyond what it has yet contracted for. The motor companies are seeking additional suitable orders.

There has been, we believe, too much dependence upon the false assumption that once you cut an industry's civilian production, its capacities are automatically transferred to defense work. This is by no means true. Necessary factory rearrangements, the designing and making of special tools, the securing of necessary machines, the selection and education of subcontractors, etc.—in brief, a "make-ready" stage of greater or less duration will intervene of necessity between the elimination of civilian production and the new defense work. The workers released from civilian production must be reabsorbed, whenever that is possible, in the new defense work, or new employment must be found for them in other factories. A very serious consideration is the fact that the present backlog of defense orders, even at full production, will not absorb thousands of men displaced by contemplated automobile curtailment.

The questions for solution are, of course, how to obtain more quickly and efficiently the vast quantities of armaments and materials needed, how to maintain continuity of employment, and how to extend rapidly to all industrial establishments, large and small, the privilege of participation in the defense work. A supreme effort is being made by the authorities to accomplish these objectives.

In four decades our industry has assembled more than 80,000,000 trucks and cars, developing as nowhere else on earth the engineering and mechanical techniques of mass production. Its management and personnel have the "know how" for the primary manufacturing and subcontracting jobs that face us, for drawing for materials and equipment and parts upon thousands of suppliers all over the country, and for scheduling the vast flow so that it will converge into the assembly of finished products.

The industry's subcontracting policies and techniques already have been carried over into its defense operations. For example: One large automobile company is paying out to suppliers of materials about forty-seven cents of every dollar of its defense contracts. The 28-ton tanks rolling from an automotive-managed arsenal represent material, supplies, and finished goods bought direct from 700 individual companies located in 130 cities in 20 states. On an important airplane job, 56 per cent of the total amount of the contracts is spent for purchased materials. Of 125 parts in an automatic cannon, 122 are being made by outside firms. Still another automotive manufacturer retains in his factories only 20 out of 195 parts in an antiaircraft gun. A large producer of army trucks sees 75 per cent of the value of the army-truck contract performed outside his own factories.

In the search for subcontractors, many unusual companies are now contributing whose previous work has been outside the regular automotive channels. One automobile company making an antiaircraft gun has farmed out work to a surgical supply house that ordinarily makes scalpels; a shovel and plow factory has taken over the gun mount; a cash register company is to make magazines for the guns. Subcontracting scattered from New England to Wisconsin covers 50 sources for machining, 41 for supply of productive material, 132 for miscellaneous supplies, and all for a single antiaircraft-gun manufacturing order.

Apart from immediate productive capacity, there is one resource of the motor industry's reservoir of potential defense service that should be noted here. If the present war becomes a long campaign, such as is being prepared for, great benefits will be bound to accrue from the motor industry's capacity for new development and research. We border here on the realm of military secrecy; but it is no secret that, from the start of the defense program, the companies comprising this industry have put at least part of their development facilities on long-range defense work. All research and experiment is an uncertain quantity. One cannot set delivery dates on ideas. But the industry's work can be counted on to deliver new ideas of value.

Many of you undoubtedly got a thrill at the anouncement that a successful method had been developed to harness a large number of automobile motors to the job of propelling 1,500-ton cargo ships. That's one way of using what we have to get the emergency job done—there will be others.

Smokeless Powder

Production of Small-Arms and Cannon Propellants

Lieut. Col. Henry N. Marsh *

WITH the mechanization of all armies, we become more and more dependent on tanks and airplanes, combat cars and trucks, but the effective use of all these new weapons in offense and our defense against such weapons in the hands of enemies primarily depend on more powerful guns and automatic fire. The efficiency of our modern weapons depends on suitable modern propellants.

Since the World War, one of the more important problems happily solved by extensive chemical research has been the formulation of propellants that are nonhygroscopic (NH) and flashless nonhygroscopic (FNH) and of higher potentials. We now have such powders for use in all our guns. The Army has at its disposal four different methods for producing these desired results. The first was designed and patented by E. I. du Pont de Nemours & Company; the second was invented by research engineers of Hercules Powder Company, the third by Picatinny, and the fourth also by Hercules. Three types are being used by the United States, England, and her allies, and advantage is being taken of the merits of each type to fulfill particular needs.

When the demand arose for increased quantities of propellant to meet the first expansion program in May 1940, there existed only two commercial concerns with practical experience and background. Their combined plant capacity was only about five per cent of the demand. About June 1937, in anticipation of the needs of this expansion, the Ordnance Department had opened an office in Wilmington where a devoted little group under the able leadership of Lieut. Col. J. P. Harris had formulated plans, selected tentative sites, and actually had purchased some of the long-delivery equipment which would be required. The services which Colonel Harris performed at that time were of such inestimable value to the smokeless-powder phase of the national-defense program that they warrant a public tribute which I am happy to pay him now.

All this work was fairly well advanced in the summer of 1940, and contracts already had been negotiated for the construction of two plants for the United States Government and two for the British. Some of the construction work was under way when, on September 12, 1940, the disaster occurred at Kenvil, N. J., which brought to our attention some hitherto unknown properties of smokeless powder. Few people even in this audience can appreciate the effects of that terrible accident. Consider but a few of them: A great number of trained men were lost. In a few seconds the country lost about a third of its existing operating capacity. A great part of the planning so laboriously done was no longer usable in the light of the disaster. Revision of all ideas required entire new designs and planning; design and construction had to work hand in hand. Finally, all this had to be done at once.

The loss of fellow workmen was tragic, and we wish to pay tribute to the survivors who have returned to work and are on the job at Kenvil. With no existing facilities, Hercules was confronted with the following tasks: (1) Revision of methods, designs, and layouts to prevent a repetition of the Kenvil disaster; (2) Redesign and reconstruction of the Kenvil plant; (3) Redesign and construction of a new British plant; (4) Construction of one line at Radford with all possible speed; (5) Preparation of a suitable layout for Radford to meet the contract requirements. This is the only one of the defense powder plants set up to produce all the types of NH and FNH powders, which include single-base rifle powder, single-base cannon powder for all calibers, double-base rifle powder, double-base cannon powder, and a special type of sheet powder for trench-mortar propellant.

Most of these things were accomplished simply by an all-out effort on the part of every man in our organization and by fine coördination of our operating, engineering, and purchasing departments. The operating department furnished the specifications, the engineering department made the designs, and, last but not least, the purchasing department so arranged their purchases that materials were received at the time they were needed.

ANOTHER tremendous task was the securing and training of personnel. All the operating buildings had been destroyed and even the heavy equipment seriously damaged and in need of repair, so we had no place to train any one. Recruiting was begun, and two types of men were secured—one for the foreman grade and a second for the supervisors. The first group required manual dexterity and the ability to handle men, and the second required high technical ability. A school was established at Kenvil and a course of lectures was prepared covering the essential operations as well as safety and labor-handling problems.

Naturally, all this instruction could be in the theory only—and such instruction is at best a poor substitute for practical experience. Once again we have to thank the Army for its assistance. Picatinny Arsenal was made available to us, and as the groups finished their theoretical courses they went to Picatinny where they were given an opportunity to see and assist in actual operations. Of course, looking back at the difficulties, they seem relatively unimportant, but at the time they gave us many a gray hair.

The War Department had told us that the rebuilding of the double-base line at Kenvil was of first importance; next in order came Radford "A" line to relieve the shortage in small-arms powder, and these were to be followed by the single-base operations at Kenvil and Belvidere. There wasn't much ground breaking to do at Kenvil, so immediately after the disaster we began clearing away the debris and preparing the site. As fast as design work was done, construction was started. Kenvil went into operation on January 23rd—just over four months after the disaster—and full production was reached March 10th.

A good idea of the progress of the work may be gained from a short chronology of the different jobs. With regard

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This is an address delivered at the Ordnance Production Session of the Twenty-Second Annual Meeting, Army Ordnance Association, October 9, 1941, the Book-Cadillac Hotel, Detroit, Mich.

to Radford Ordnance Works, the prime contract was signed August 16, 1940, and the first ground was broken less than a month later. A material addition to the contract was signed November 22, 1940, increasing the size of the plant from two lines to three and adding double-base manufacturing facilities. The first plant map was not approved until December 4, 1940, and it was only on this date that real work could be started on foundations and roads. By this time cold weather was on us. The estimated completion dates for the various lines were: "A" line, March 15, 1941; "B" line, June 15, 1941; "C" line, July 15, 1941.

IT is interesting to look at this schedule and see how closely we lived up to our expectations. A ceremony was held at Radford officially opening "A" line on schedule on March 15, 1941, though little powder was produced there until early in April. (Kenvil's single-base line started on March 14th, and Belvidere went into production April 14th.) Radford's "B" line was completed and ready for operation on June 20th, only five days late; "C" line started producing powder on September 10th, nearly two months behind schedule.

For all these operations, the powder and explosives section of the Ordnance Department has scheduled the quantities and types of powder to be produced at Radford. We are pleased to state that we have stayed very close to schedule, and by this date we have granulated a quantity equal to the quantity that was on the schedule. With justifiable pride we report to you that Radford Ordnance Works is now producing more than its stated capacity every working day.

While we were in the midst of all of this, the War Department asked us to undertake another job of a type with which we had had no practical experience. The Department found it necessary to build a bag-loading plant in the general locality of the Radford plant. Perhaps we should admit some familiarity with this operation as some of us had seen smokeless powder and powder bags and to that extent were further advanced than others with similar contracts!

To get a better perspective of the job, we sent men to Curtis Bay, Picatinny Arsenal, and Iona Island where such operations were being conducted. Through the coöperation of the Hercules operating and engineering departments and the Army Ordnance Department, a new design was produced, radically different from the war-plans design, which was believed by all to increase the safety of the operation and reduce man exposure. This design has been adopted for use in the construction of the other bag-loading plants.

THE contract for a bag-loading plant on a site near Pulaski, Va., was signed December 17, 1940, and we did not get on the site until early in February. Ground was broken on February 10th, but no serious work was done on the plant until after April because the Ordnance Department wanted nothing to interfere with starting the "A" line at Radford. Despite this slow beginning and the difficulties of designing an entirely new layout, the first unit at the New River plant went into operation September 24th, and the second is scheduled for October 15th, with the others to follow at 2-week intervals.

Again the most interesting part of this job was to secure and train the requisite personnel. Here, as for smokeless-powder manufacture, we picked up various types of men for either labor-handling or supervisory work. These men were trained in actual operations at Picatinny and Curtis Bay, and we were fortunate in filling the higher positions with most capable men. For supervisors and foremen we had the assistance of the Virginia State Employment Commission who gave dexterity tests to such of the personnel as were selected from the immediate vicinity, and those who passed the tests went to Picatinny and Curtis Bay for training.

Meanwhile, some of the buildings had been completed, and we started a practice school in one of the warehouses. Space was laid out for the various operations, and cloth-cutting machines, printing presses, stamping dies, and sewing machines were installed in one end of the building. At the other end were built booths simulating the size and character of the actual operating rooms in which were installed all the powder-handling equipment, such as chutes, scales, and sewing machines, just as it would be in actual operation—the only difference being that cracked corn was substituted for smokeless powder and wheat for black powder. The same safety rules as would apply in operation were enforced. This school has been of tremendous help in the training of operators for safe and efficient operation at New River Ordnance Plant.

Much praise for the progress of the work at both plants must be given to the Mason & Hanger Company which was our contractor for construction at Radford and the construc tion contractor for the New River Ordnance Plant. Following are a few construction high lights for the two plants: Total excavation, 5,000,000 yards (equal to the yardage moved in building Shasta Dam); total miles of road, 100 (more than enough to reach from New York to Philadelphia); total miles of fence, 37; number of permanent buildings, 800—not to mention a railroad bridge over a state highway and a 1,100-foot steel-span bridge over New River; a water-pumping and purification system with a capacity sufficient to handle the needs of a city the size of Buffalo; and had all the freight cars which moved into these two jobs been assembled in a single train, it would reach from Detroit to Pittsburgh.

PERHAPS there is one lesson which may be learned from these experiences—in all the conferences over the last several years regarding the industrial-preparedness program, it was agreed that plans might be made, equipment purchased, and sites located for whatever needs there might be, but it was recognized that the principal problem in such an expanded program was the training of personnel. The training of such personnel will be the duty and obligation of those commercial concerns most closely related to the particular problem in their everyday life. These two jobs have required the training, in 8 months, of a total of 6,000 men able to take over the operation of a powder-producing plant—and the men to be trained were, in most cases, farmers and unskilled laborers. We have shown that with the background of commercial experience such a job can be done. (EDITOR'S NOTE.—A new smokeless-powder plant at Merrimac, Wis., to be known as the Badger Ordnance Works, has been announced by the War Department. The new plant will be Government-owned and will be controlled by the Ordnance Department.)

We cannot close this paper without stressing the wholehearted one hundred per cent coöperation we have received from the Ordnance Department in solving the problems that arose—their wide knowledge in this field and far-sighted planning was of immeasurable assistance to us. We bring to the Army Ordnance Association a salute from the first powder plant to get into production and the first to reach its stated capacity.

The Army Maneuvers

Tanks are playing an increasingly important rôle in the strategy and tactics of our modern Army. A 28-ton medium M3 tank is shown above during war games in the South (Acme photo). This modern combat vehicle carries a 75-mm. gun, a 37-mm. gun, and several machine guns. Light tanks are shown below advancing rapidly through a smoke screen.

Lessons in Mobility for the New Army

The Armored Force of the U. S. Army is not stopped by natural or man-made obstacles. Led by a ¼-ton command-reconnaissance car, motorcycle troops with the 2nd Armored Division of the Third Army, above, detour around a "bombed" bridge during maneuvers. Below, the 17th Engineers build a ponton bridge across the Sabine River.

Maneuvers Test Horsepower and Manpower

The 107th Cavalry Regiment of Ohio, horse and mechanized, is shown above on a mission in the Second Army maneuvers in Arkansas. Below, "jeeps" and scout cars of the 41st Infantry of the 2nd Armored Division roll over a ponton bridge constructed by the 17th Engineers across the Sabine River during fall maneuvers of the Third Army in Louisiana.

The Men Behind the Guns

Maneuvers mean tedious details as well as fast action. The soldier must eat, and men of the Third Army, above, are unloading meats from a railroad car into a supply depot at Lake Charles, La. Below, members of a 75-mm. gun battery are cleaning their piece after a "battle." The 75 is being used in increasing numbers as an antitank weapon against heavier tanks.

Ordnance Training

Field Service Maintenance Looms Large on the New Horizons

Brig. Gen. Julian S. Hatcher*

THE success of the Ordnance Department's stupendous armament program is now assured. Quantity production has already been reached in every class of ordnance, and from now on, tanks, guns, instruments, and ammunition will be coming off the production lines in unbelievable and ever-increasing volume.

With the help of American industry, the Ordnance Industrial Service has thus hung up an all-time record for performance. It has most thoroughly fulfilled its mission and will continue to do so until the end of this emergency. But, magnificent as this accomplishment is, it still does not insure the success of the Ordnance mission—of which the armies in the field will be the sole and final judge. The reputation with which the Ordnance Department emerges from the present war will depend, not on how much armament was produced for ourselves and others, but rather on how well we satisfy the instant needs of the field forces in the combat zones. Thus something more is needed than the magnificent production of enormous amounts of ordnance.

This "something" is *Ordnance service to the field forces* which is supplied by our Ordnance soldiers. These soldiers must see that guns and ammunition are supplied to the troops when and where they are needed and that maintenance is prompt and efficient. To an army fighting in some far-off theater of operations, a gun or a tank repaired and returned to action is worth a hundred coming off the production lines back in the zone of the interior. It is to our Ordnance officers and soldiers in the field that the armies look to keep the tanks rolling, the guns shooting, the ammunition on hand and the instruments in repair. Our officers and soldiers in the field must be truly efficient by reason of their superior technical training if the Ordnance Department is to get full credit for its magnificent industrial accomplishment.

AT the beginning of the emergency, the Army had an Ordnance Department of 324 officers and about 3,000 men whose sole training facility was the Ordnance School with a capacity of 10 officers and 160 enlisted students a year. Overnight we were faced with the problem of expanding the school into a training center to give military and basic ordnance training to some 24,000 enlisted students and advanced technical training to some 1,600 officers and 6,000 soldiers a year. In addition, we were to organize and train 26 new maintenance companies and 16 new ammunition companies within the first 6 months. The percentage of expansion involved was enormous. Few of our readers will realize that the Ordnance military personnel has expanded since the beginning of the emergency to a proportionately greater extent than that of the Air Corps.

Our solution was to establish an Ordnance training center consisting of several training echelons, each with its own commander but all grouped under the training-center commander to form an integrated establishment for complete training of every type of military Ordnance personnel. The largest echelon is the Ordnance Replacement Training Center with a present authorized strength of over 7,000 men. Its function is to take in raw selectees and give them four weeks' intensive military training first to make them soldiers, followed by nine weeks of basic technical training in ordnance. After these thirteen weeks' training, they go to the field as fillers or loss-replacements for Ordnance units with the field armies, the Armored Force, Air Force (Aviation Ordnance) and other combat units.

Another echelon, the Ordnance School, graduating 150 officers a month, plus 1,250 enlisted students every 3 months, gives advanced technical ordnance training to students who are sent in from the field. In addition, it operates an officers' candidate school in which carefully selected enlisted men are given a chance to earn a commission in the Army. The Unit Training Center had the task of organizing and training twenty-six entirely new maintenance companies in the first six months of operation.

For many years the Ordnance School was located at Aberdeen Proving Ground, Md., to enable the students to observe the many tests being conducted there and to see the large variety of modern ordnance matériel always on hand at that station. When the new Ordnance Training Center was established, it was likewise natural that it should be located near the proving ground. The training center was established, therefore, on newly acquired land adjacent to Aberdeen Proving Ground and now operates as a subpost known as Camp Rodman. Construction was started on January 18, 1941; two months later, the first thousand selectees moved in; in two more months, by May 18th, approximately ten thousand men were in the camp.

A year now has passed since that day in January when ground was first broken for Camp Rodman. During this short existence, the Ordnance Training Center has passed many thousands of officers and men through one or more of its subordinate elements. The record of the first year has been largely one of expediency—of having to deviate to some extent from ideal objectives and from set plans in the face of realities. These realities consisted of the rapid expansion of the whole Ordnance military personnel as well as of the training center itself, the exigencies of a large construction program, the difficulties (with priorities in existence) of getting the large amounts of equipment in ordnance matériel necessary to train the large number of officers and men who pass through this training center, and many others.

As an example of these deviations, we may cite the curtailment of the length of the officers' course from two years in the piping days of peace to three months, and finally to one month—with an extra month thrown in whenever possible; and the reduction of the enlisted men's courses from nine months to three months. As another example, we can cite the early operation of the replacement training center, which is supposed to give each recruit thirteen weeks' training, but which, faced with the necessity of providing fillers for twenty-six new maintenance companies, eight ammunition

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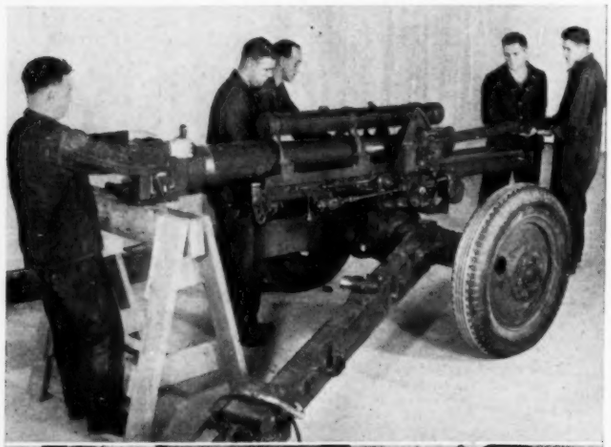
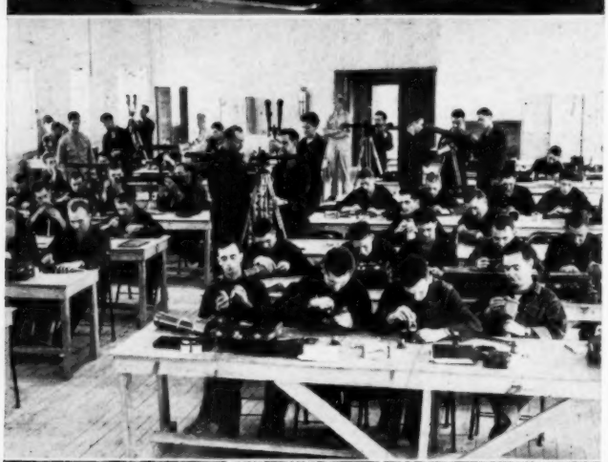




companies and a great many aviation ordnance companies, was obliged to "graduate" some six thousand men before the completion of their full thirteen weeks' training. Under the stress of emergency conditions it was necessary for them to obtain the remainder of that mandatory first training in the units to which they were sent. Only after the replacement training center had been in operation for several months was it able to settle down to giving every man thirteen full weeks of training.

NOW, however, that the training center has completed its first year of existence, we have leveled off. The Army has reached its full strength under the present authorization, and the training center has accomplished its first big expansion from a single training company to an organization of some ten thousand men. No matter how much the Army is increased in the future, it never will involve such a percentage expansion of the training center as we went through during the first few months.

What is this "level condition" as it applies to us here? First, the construction is complete, and reasonably satisfactory housing and instruction buildings are in existence. Secondly, the local equipment shortage has passed the critical

←—Students at the Ordnance Training Center, Aberdeen, learn artillery maintenance, shop practice, and instrument repair; outdoor training hardens up recruits.

stage. Thirdly, we are no longer under extreme pressure in the matter of getting men into and out of the camp. The selectee is assured of thirteen weeks in the replacement training center and the student in the Ordnance School is assured of a three months' stay. In such a situation, we must be alert to avoid the danger of becoming satisfied with procedures of expediency after the good reasons for those procedures have vanished. Their very success (as measured against the previously existing conditions) will have a tendency to blind us into complacency. We must not let this happen. On the contrary, having reached the plateau, we must pause to regain sight of our objective and then proceed to it by the improved methods made possible by new conditions.

We must remember, as was stated above, that the armies in the field will be our judges and that, in the end, our success will be measured solely by the degree to which we meet the needs and demands of the troops in the field. Consequently, we must keep in touch with the field forces and learn their needs and desires by first-hand observation; otherwise, we may find ourselves thinking and teaching 1918 instead of 1942.

In line with this reasoning, it has been my policy to go myself and to have my staff and the faculty and students of the Ordnance School go in turn, as they could be spared from their duties here, to every command-post exercise and field maneuver and to visit the other service schools and training centers.

The objective of the Ordnance Training Center, its commander and staff, is to insure that Ordnance troops will give the Army exactly the kind of Ordnance service it wants. This means to coördinate and direct the operation of the Ordnance Replacement Training Center and the Ordnance School by keeping in close touch with the military functions

and the training objectives of the Ordnance Department.

The mission of the replacement training center is to be able to furnish men to replace losses in Ordnance field units. The replacements must be sufficiently trained so that they can step right into an average job in an Ordnance company and perform it with a minimum of supervision. To accomplish this, the individual must first be processed and equipped. Next, he must be given the essentials of soldiering common to all branches and services. Then he must be taught a specialty, for when he fills a vacancy it will be as an armorer, automotive repair man, munitions worker, machinist, or some other such technical position.

The mission of the Ordnance School is, broadly, to furnish advanced technical education to Ordnance officers and enlisted men. In its former peace-time operations the quality of its students was limited to the type of men who happened to enlist for the Ordnance Department under our volunteer system of recruiting. Many of the men sent in from the field had relatively limited previous experience and the school was forced to give much time to elementary and basic Ordnance training as well as to the more advanced phases. Hence the school term for most specialties was nine months instead of three months as at present.

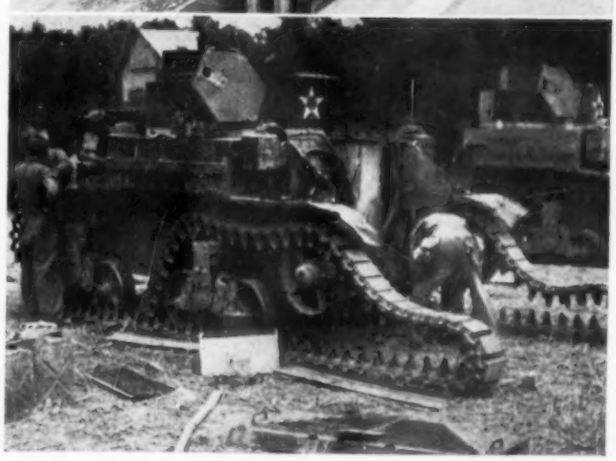
The Ordnance Training Center also teaches⟶ welding, small-arms repair, and the maintenance of armored vehicles to keep the Army in fighting trim.

When the emergency came, the school became almost entirely a replacement center for specialists. The expansion so diluted the skills of the old Regular Army men and so lowered the average standards of the field organizations that the students they sent in were little more than recruits. The Ordnance School of necessity, therefore, had to emphasize the more basic and elementary training at the expense of the strictly postgraduate subjects.

The services of the school in performing this most urgent emergency service can hardly be exaggerated. But times have now changed; the greatest percentage expansion is now accomplished, and both the training center and the field organizations have finished with their growing pains. The field units are now equipped; there is more and more ordnance matériel on which they can work and upon which they can develop their own skills. They will cease before long to be plagued with new recruits, and all their fillers will be men who have already received the full thirteen weeks in the Ordnance Replacement Training Center.

These circumstances soon will relieve the school of any necessity for giving elementary instruction in the specialties. It will then be able to step almost completely into the realm of postgraduate functions and need not accept as a student any man who does not already have a good basic understanding of his subject received in the replacement training center or elsewhere.

Thus the Ordnance Replacement Training Center to receive the raw recruit and give him his basic military and ordnance training and the Ordnance School to concentrate entirely on the higher and more complicated phases of Ordnance education will form, under the guidance of the Ordnance Training Center commander and staff, a team that can be counted on to deliver what the Army wants in personnel training for Ordnance service in the field.



Light Tanks

Building the Army's Fast Combat Vehicle

Charles J. Hardy*

THE American Car and Foundry Company, familiarly known as A.C.F., is, I am proud to say, actively engaged in the mass production of ordnance for the national defense. I may add also that our activities in the line of national preparedness are not confined to ordnance alone but embrace a wide range of other instrumentalities to that end; for example, shell forgings, demolition bombs, pontons, tank lighters, mine sweepers, fuzes, metallic containers for the transport of chemicals, etc. But of all these activities, none exceeds in either volume or importance what we have done and are doing in the production of the light combat tank.

A.C.F. is primarily a manufacturer of railroad equipment and rolling stock but with the peculiarly American ability to adapt its facilities and resources to other ends and purposes. Twenty-odd years ago, when the World War threatened to bring all civilization into chaos, our company, practically overnight, became one of the largest producers of armament—shells by the hundreds of thousands, gun mounts, railroad gun carriages, artillery vehicles, and innumerable other articles needed in the conduct of that war—a war designed to end all wars which, unfortunately, failed of its purpose. With that war ended, we returned, as promptly as we had left them, to the peaceful if somewhat humdrum pursuits of an humble purveyor to the transportation needs of our country. And so we remained, until there appeared on the horizon the foreshadowing of the frightful cataclysm which now engulfs practically the entire world and which, if unchecked, threatens the extinction of our American way of life and of the ideals for which our forefathers fought and suffered and to the perpetuation of which our people have dedicated their every effort.

ON July 31, 1939, there came to us from the Ordnance Department of the United States Army an official inquiry for the production, in mass, of the light military combat tank—a "contraption" weighing thirteen tons, propelled by a 250-horsepower radial-type engine located in the rear, carrying a crew of four men and a 2-way radio, and armed with a 37-mm. cannon and heavy and light machine guns—all protected by varying thicknesses of armor plate accounting for thirty per cent of the entire weight of the machine, and capable of a speed of from forty to forty-five miles an hour over the roughest terrain.

In our survey of the field in which the skill, experience, resources, and technical knowledge of our company might usefully be employed, we had given special study to the possible production of this so-called light combat tank. We knew that the tank—which, curiously enough, had its first conception in the minds of the British Navy—had made its debut in actual warfare with the British Army at Cambrai where its value as a fighting machine, a veritable moving fortress, was definitely established. We knew that while the tank, as a weapon of war, was the joint product of American, French, and British inventive genius, yet its chief value lay in the mobility given it by an American idea—the so-called caterpillar traction device.

We knew that late in 1917 it had been decided to supply the United States Army with two types of this new fighting machine—one the large size, favored by the British, capable of containing a dozen men, and the other, favored by the French, weighing about six tons and carrying two men and a machine gun. And we knew that with the signing of the Armistice in November 1918 the importance of the tank as a fighting unit had faded from the minds of the general public. But the inquiry of July 1939 brought with it the realization that the combat tank was a matter of prime importance with the Ordnance Department of the United States Army.

The combat tank of today and its functions have been described by Lieut. Col. J. K. Christmas, Ordnance Department, in this language: "The fighting tank concentrates in one compact, balanced, and self-sufficient machine all the sprawling complicated and loosely organized functions of a muscle-propelled division—but the tank does it better. Machine-gun fire, artillery fire, the mobility of cavalry, the protection (but mobile) of trenches, antiaircraft fire, radio communication, rationing of men and machines for a long movement, transportation for the wounded, shelter against the elements and the transportation of necessary equipment—all these can be and are provided by one machine, the tank" (Army Ordnance, January-February 1941, Vol. XXI, No. 124, p. 363).

It surely was a far cry from the tank as we knew it in 1918 to that covered by the Army's inquiry of July 1939, and just as surely was it a far cry from building an ordinary freight car to turning out so complicated a work of precision as the tank, adapted to and capable of discharging all the functions enumerated by Colonel Christmas, as demanded by the specifications accompanying the inquiry of two years ago.

That inquiry, as I have intimated, did not find us unprepared. The whole problem had been given most careful and comprehensive study, not only by our technical staff but naturally by our management also. The complexities and difficulties of the undertaking, operative as well as financial, had not been minimized in our consideration of the problems presented, and of such problems there were plenty. Management and operations found common ground of agreement. The "go ahead" was given. Estimators, engineers, shop foremen, and executives worked day and night without ceasing, and, on September 28, 1939, our bid was submitted. Five days later, on October 3, 1939, we were awarded a contract for the making of 329 of these light military combat tanks—the first "tank contract" let by our Government.

AT the start, there was a little matter of more than 2,600 blueprints to be checked, rechecked, and approved as a preliminary of the requisitioning of materials. Then shop space had to be provided; tooling up had to be done; machines had to be procured and, when not procurable, had to

*President, American Car and Foundry Company, New York, N. Y.
This is an address delivered at the Ordnance Production Session of the Twenty-Second Annual Meeting, Army Ordnance Association, October 9, 1941, the Book-Cadillac Hotel, Detroit, Mich.

LIGHT TANKS ON THE PRODUCTION LINE AT AMERICAN CAR AND FOUNDRY COMPANY

be made. In the building of one of these tanks, exclusive of the engines and accessories, there are involved 14,318 individual pieces of 2,865 different designs. The machining work requires 2,728 operations on 705 individual items and machines and machinery of all kinds almost beyond count.

When I said a few moments ago that the complexities and difficulties of our undertaking had not been minimized, I was guilty, perhaps, of an understatement with respect to the armor plate needed at the times and in the quantities to meet the demands of our schedule of deliveries. We had calculated upon purchasing this from established sources of supply but soon found that such sources were inadequate to meet our demands. This presented a problem indeed, but needs must when the devil (euphemism for the Ordnance Department!) is driving, so we were compelled to make our own. This was an entirely new field of endeavor even for A.C.F., but rushing in where perhaps angels feared to tread, we did what seemed the impossible and today are the largest producer of case-hardened armor plate in the world, supplying not only our own needs but those of other builders of armored equipment as well. We now are also producing homogeneous armor plate for ourselves and for other manufacturers.

To go back at bit: The contract for the first 329 tanks was placed with A.C.F. on October 3, 1939. The pilot tank, with soft-steel plates, was completed by January 1940. The first armor-plated tank was started March 22, 1940, and was completed and accepted April 30, 1940, sixteen days ahead of our promised delivery date. The entire 329 tanks contained in the first order placed with us were completed in December 1940—again ahead of schedule, and this despite the fact that, due to numerous changes in design made as the work progressed, we would have been entitled to additional time to complete our deliveries had we so requested.

We have traveled far since October 1939, with its contract for 329 tanks—a large order at the time but small in retrospect. On August 2, 1941, we celebrated the delivery to the United States Army of the one-thousandth tank to roll off our delivery line at our Berwick plant, and I violate no confidence when I say that very shortly we shall make delivery of the two-thousandth tank. For obvious reasons, I do not care to go into details of production, but without doing so I may tell you that A.C.F. is now producing at the rate of 400 tanks a month and expects shortly to reach a production of 500 monthly with a later monthly goal of 600.

It is perhaps proper to say here that in this undertaking of ours the entire financial risk, which was not inconsiderable, was assumed by A.C.F.; its own money, and only its own money, has been used in the purchase, construction, and preparation of the buildings and facilities needed. We asked no Government help, nor did we invite the Government to share our risk.

ALL this has been done without impinging upon our ability to produce as required the equipment needed by the railroads of the country to enable them to play their part in the program of national preparedness. Let me add also, and stress the fact, that A.C.F. claims no credit for the design of the tanks it produces. You all probably have seen the newspaper reports to the effect that several hundred of these tanks produced by A.C.F. have come gallantly through their "baptism of fire" with the British forces in the recent Grecian and Near Eastern campaigns and that the British Government has approved them as first-class fighting units on the basis of exhaustive tests in active service in Libya under the same conditions that wrecked the best designs which British manufacturers could produce. Let the credit be placed where it belongs, and that is with the Ordnance Department of the United States Army. Speaking recently on behalf of our company at our Berwick plant I said, and I now repeat:

"Ours has been the hand that performed; the brain that conceived is the Ordnance Department of the United States Army. . . . I pay my tribute of admiration and praise to that Department, to its staffs, and to the individual members of those staffs at Rock Island Arsenal, at Washington, at Philadelphia, and here at our works at Berwick itself, for the spirit of good will shown and the unstinted, intelligent, and always-helpful coöperation at all times given us in our efforts, happily successful, to become a contributing factor in the great work of preparedness so imperatively demanded for the defense of our country and the preservation of its ideals of life and government."

The New Semiautomatic Carbine

The Army Adopts a Light Rifle in Record Time

Lieut. Col. René R. Studler*

THE War Department recently has announced the adoption of a new infantry weapon. Its official name is "U. S. Carbine, Caliber .30, M1." This announcement marks the completion of exactly one year's intensive work on the part of the Army Ordnance Department, the Office of the Chief of Infantry, and several major arms manufacturers, as well as independent inventors.

In October 1940, a circular was first issued, listing the requirements for a new weapon and outlining the tests to which it would be subjected. Efforts were made to place this circular in the hands of all small-arms manufacturers and leading gun designers of the United States. There was a generous response to the circular, and there evolved nine designs which merited consideration.

The need for a new weapon for the individual soldier—one that would weigh little but hit hard—resulted from a change in tactics and was made apparent when it was seen that rear elements often became suddenly confronted by the enemy at close range. Previously, it had been found that a pistol was sufficient for personnel serving machine guns and other team-operated weapons. When the Nazi spearheads began to penetrate the Allied lines and parachutists appeared in the rear areas, the defenders had no weapons which could adequately reply to their fire.

What is needed, it developed, is a light but powerful weapon. It must be light because it must be carried by the soldier in addition to the equipment which he carries for his team weapon. Secondly, it must compare favorably with the fire power of the enemy infantry. This requirement indicated a rifle, as the low velocity of a pistol or revolver makes either unreliable at ranges beyond a few hundred yards. Thus the carbine and its cartridges were conceived. The carbine is light and short for portability; the cartridge has a light bullet and high muzzle velocity for increased striking power at distances beyond practical pistol range.

Production of the carbine involved an investigation into the most intimate and basic details of gun and ammunition design. It first was necessary to design a cartridge to meet the ballistic requirements. This was completed in December 1940. There was no military weapon of the desired type in existence, and no commercial weapon of such light weight handling so powerful a cartridge was available. In spite of these handicaps, eight rifles were submitted to the Ordnance Department on May 1, 1941. The board of officers who examined these entries declared that six were worthy of test, and this was immediately undertaken by the Aberdeen Proving Ground. By working under pressure, thorough tests of these guns were completed by the middle of June.

These six rifles represented, in the judgment of their individual designers, the nearest possible approach to the gun described by the original circular. None of the models met the requirements exactly, but all were so close it was believed that any one of them, with some additional development, could be redesigned within the limits prescribed.

These rifles have been described in the September-October 1941 issue of ARMY ORDNANCE (Vol. XXII, No. 128, p. 225), so the following brief tabulation shows only the over-all length, weight, and type of mechanism of these models:

Weapon	*Length (inches)*	*Weight (pounds)*	*System*
Auto-Ordnance	35	5.5	Recoil
Harrington & Richardson	38	5.8	Inertia
Hyde	34	5.3	Gas
Savage	33	5.2	Recoil
Springfield	35	4.9	Gas
Woodhull	30	5.5	Inertia

It should be noted that these rifles represent three different types of operation: gas, recoil, and inertia. Further, they were individually developed by men who are designers for leading manufacturers of small arms or are well known as private gunsmiths.

AS the sultry summer weather grew more oppressive at the proving ground, the relentless tests began to develop weaknesses and faults in the guns. In one, a spring would break, in another an extractor—or a gun would develop that mysterious trouble known as "failed to function." The proof officers carefully compiled voluminous statistics listing with equal favor fine accuracy groups and discouraging malfunctions.

During these tests, which were closely observed by Army personnel from all combat branches eager to learn the habits and possibilities of the new weapons, evidence was gathered which led to loosening some of the restrictions originally placed on the design. For example, the gun was no longer required to incorporate both automatic and semiautomatic actions, nor was it required to function satisfactorily with a magazine containing as many as fifty rounds.

At the conclusion of the preliminary tests, it was decided that the rifle submitted by George Hyde and that submitted by Springfield Armory were worthy of further Ordnance and service tests, provided the rifles were modified in certain respects. Thereupon additional models of each type were ordered for further tests. In June 1941, the Ordnance Department announced that a service test of the light rifles would start on September 15, 1941, and would be completed by September 30, 1941.

During the summer months, consideration was given to rifles that had failed in their preliminary tests but had been modified in an attempt to overcome the original faults. Consideration also was given to "late starters" in the competition. Prior to September 15th, R. J. Turner submitted his rifle to the Ordnance Department. This rifle was gas-operated, weighed 4.2 pounds without magazine or sling, and was 34 inches in over-all length. As originally submitted, it was an all-metal weapon, but preliminary tests soon indicated the desirability of a wooden forearm and stock.

About this time the Winchester Repeating Arms Com-

*Executive Officer, Small Arms Division, Industrial Service, Office of the Chief of Ordnance. Lieutenant Colonel, Ordnance Department, U. S. Army.

THE WINCHESTER SEMIAUTOMATIC CARBINE, CALIBER .30, M1

pany also submitted a gas-operated rifle. This weapon was 35 inches long, including an 18-inch barrel and weighed 4.6 pounds without magazine or sling. It was remarkably simple in construction and very pleasing to the eye. This favorable reaction was continued and strengthened as the gun progressed successively from one test to the next. That this gun could perform so well under the grueling trials could hardly be believed by those who knew that scarcely six weeks had elapsed since the first lathe tool had started its fabrication.

In the meantime, it had become increasingly apparent that if the branches of the Army interested in this weapon conducted their tests individually, much time would be consumed. As the Infantry, Armored Force, Field Artillery, Cavalry, and Engineers all were concerned, the number of weeks that could be lost by having each arm conduct its own test, together with time lost in repairing the guns between tests, would be greater than the emergency permitted.

To expedite this work, the Ordnance Department proposed that the Infantry conduct the service test at Aberdeen Proving Ground about September 15, 1941. In line with this proposal, the Infantry was to prepare the test program which was to be submitted to and concurred in by the other interested branches. The tests conducted under this program were to be executed by Infantry personnel. Further, in the event that additional tests might be required by arms other than the Infantry, the proving ground was available for these tests. This arrangement was not limited to the Army. Representatives of the Navy and Marine Corps, too, visited the tests and engaged in the firings. (Their agreement with the findings of the board has recently been signalized by the placing of a substantial order for the new carbine by the Navy Department.)

With the Infantry furnishing the organization and personnel for these tests, the Ordnance Department contributed by making available a large area at the Aberdeen Proving Ground. During the period September 15th to September 30th, required for the tests, this region was in effect a portion of the Infantry Board's facilities at Fort Benning, Ga. The technical personnel necessary to service and mark targets, to compile and reproduce the test records, were furnished from the employees of the proving ground. Due to these teamwork arrangements, within two weeks it was possible to conduct an exhaustive test, under simulated combat conditions, of the five types of rifles available.

On September 15th, the following rifles were presented for the service test: Springfield, Hyde, Winchester, Turner, and Reising. The detachment of officers and enlisted men from Fort Benning put each rifle through its paces. Testing started early each morning and lasted until dark. Each model was tested by each soldier in turn. The rifles were fired "dry," with dust in the mechanism, after a mud bath, rapid fire, slow fire, from all positions, during skirmish runs—in fact, under all known conditions of severe service. The tests were conducted on schedule, and the last few days of September found the test personnel, assisted by the Aberdeen technicians, reducing data, assembling records, drawing conclusions, and skillfully working the report into its final form.

SEPTEMBER 30, 1941, exactly one year after the initial announcement, the subcommittee charged with the selection of a light rifle convened. The report of the test board was presented, discussion of its findings ensued, and doubtful or unfamiliar points were cleared up. Finally, agreement was reached as to last-minute, perfecting modifications, and with unanimous agreement the Winchester entry was recommended for adoption.

Later in the same day, a special meeting of the Ordnance Technical Committee was held, and the findings of the subcommittee were presented. The findings were received and approved, and a new Army team—carbine and cartridge—was recommended to higher authority for approval. This necessary clearance was soon obtained, and the development and experimental phases were completed. With the adoption of the carbine and its inclusion in the Ordnance Department's Book of Standards, the work is not finished. Facilities for its manufacture must be provided, production schedules must be worked out, and the necessary raw materials assembled.

This work is continuing at the rapid but careful pace which marked the development. Already tooling is under way and contracts for manufacture are being negotiated. Within six weeks of the date of standardization, five production models of the carbine were delivered to the Chief of Ordnance. These guns will be checked against production drawings and thereafter will be subjected to extensive endurance tests. The tests will provide the basis upon which maintenance procedure, training manuals, and other necessary data will be based. Thus, the announcement of standardization is not the end of the story. The main activity has but shifted from the Army to American industry; it now has the task of producing America's latest and handiest weapon for the individual soldier.

Shell Production

Motion Pictures as an Aid to Quantity Manufacture

Lieut. Col. Roy L. Bowlin*

IN compiling its production analysis of a recent educational contract for 75-mm. shell, the General Railway Signal Company of Rochester, N. Y., adopted an expedient that may prove valuable in relation to other ordnance material now being produced under the defense program. After careful study and experimentation in tooling, operation, and methods of manufacture, the usual production analysis, consisting of time study, production data, drawings, and photographs, was assembled according to contract stipulations outlined in the educational order. To supplement these data, it was decided to produce a motion picture showing the entire sequence of operations, close-up details of tools and operators, spacing of machines, scrap quantity, and many other features not presentable by any other practicable method. With the combined written and picturized analysis considered as a guide to other manufacturers who may in future be engaged in the machining of 75-mm. shell, the film portion may be regarded as a significant, valuable, new application of the motion picture to instructional purposes.

MACHINING GILDING-METAL BAND ON 75-MM. SHELL

The motion picture is not intended to replace any part of the written production analysis required on educational orders. Its purpose is to supplement the analysis by utilizing the same power of vivid action presentation that has made motion pictures a widely used teaching aid in general education.

Theoretically, a written analysis tells the whole story of any mechanical procedure in complete detail and with complete clarity. Militating against this, however, is the barrier of language—the problem of getting a detailed account, in words, of exactly what is done and the lack of certainty that the description, once formulated, will be correctly interpreted by every one reading it. Using its motion picture as a supplement, the General Railway Signal analysis leaps this barrier of words and gives the observer the entire machining procedure in the form of actual experience carefully visualized. The picture helps to close the gap between the written description and actual operation. It enables the onlooker to see what is meant—how machines and tools are doing the job. It lends final authority to the production analysis by making the onlooker an eyewitness to the effectiveness of the methods employed.

Although the motion picture shows only an educational-order tooling set-up and processing line, the methods of machining pictured are the result of careful research, study, and experimentation. From the line of tools shown and from the experience gained in the production of the educational order, it is a short step to determination of the methods of machining, handling, assembling, and processing that could be economically used in a quantity-production line.

The usual procedure for a manufacturer upon receiving a request to submit quotations or determine his ability to manufacture shell is to educate his organization on methods of processing. To do this, he must, as a rule, visit other manufacturers who have gained that experience by actual production. In some instances, weeks and months are lost before he can confidently advise the Ordnance Office as to his ability to undertake a shell contract.

Study of other manufacturers' methods permits him to determine whether he has available machines to accomplish necessary operations or if the purchase of new equipment is necessary. He learns of the required floor space, methods of handling shells, scrap disposal, and—more important—the economical sequence of operation and machining methods. In machining processes there is, of course, a choice of solutions—a variety of alternatives. New methods of machining and the number of machines to accomplish desired results are available and known, but how and when and in what sequence they are to be used are problems which must be worked out. It is, obviously, the job of the engineers to adapt the machines to the purpose at hand in such a way as to attain the highest possible quality and speed at the lowest possible cost.

THE General Railway Signal motion picture eliminates the major portion of this preliminary study for a potential shell producer. He sees the equipment used, the floor space, spacing of machines, the tools used, the machining methods, the sequence of operations, and the result of each operation, step by step, both in general view and in detailed close-ups. From the moment the rough forging is placed in the shot-blasting machine, the procedure is followed in sequence through every operation. Operating time is given for every operation as actually checked in the educational line-up of machines, and the figures thus established, though in many instances capable of improvement in quantity manufacturing, are valuable guides in designing a production layout.

The information conveyed to the potential shell manufacturer as he views each operation would enable him, with the aid of the written analysis, to arrive quickly at a decision; whereas, under the system of observing other manufacturers' equipment, he normally would need months to reach this point. This does not mean that he would merely copy what

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he observed in the picture, but that by drawing on his own experience and adapting available equipment to the methods demonstrated in the motion picture he could formulate a general scheme of processing and apply it to a quantity-production layout.

The film shows the operators at each machine in sequence, with a detailed close-up view of each of the twenty-two machining operations, as follows: shot blasting, centering base end of forging, rough turning, cutting off open end and facing base, forming nose, rough boring and finishing, finish turn and forming grooves, facing base and knurling band seat, drilling and tapping for set screw, milling thread in nose, notching nose, stamping, washing, preliminary Government inspection, spot welding cover on base, assembling set screw, weighing, painting, and packing in cartons. Between operations the shop inspections for each operation are shown—completing a very comprehensive study of each operation.

PRESSING GILDING-METAL BAND INTO GROOVE

The motion picture, entitled "Machining 75-mm. Shell," was produced with the assistance of the Teaching Films Division of the Eastman Kodak Company. It is made on 16-mm. full-color Kodachrome film. In this instance, color is not introduced primarily for æsthetic effect, but is used for the very practical purpose of reproducing, as nearly as possible, actual operating conditions. Aside from the general feeling of complete realism which it gives to the whole manufacturing procedure, it reveals distinctions not readily discernible in monotone. It serves, for example, to make the gilding-metal band stand out unmistakably from the shell surface, and visualizes to the last degree such steps as painting the inner and outer surfaces of the shell.

BESIDES color, the picture has a commentary in sound, which is employed for such specific purposes as identifying machines and operations and to announce the exact time required for the various steps as they were carried out in machining the educational order. The device of sound was considered essential to the effectiveness of the film because it not only brings together necessary explanations and their corresponding scenes but synchronizes them as well. If the picture continuity were broken by titles, as in silent films, the onlooker would be forced into another medium—that of the printed word. With sound, audible explanations are, of course, simply "superimposed" over visual images, as in most present-day entertainment pictures. Hearing reënforces vision, and the combination produces a more complete and effective impression. At the proper time the appropriate words are spoken—without interrupting the flow of the picture continuity.

The continuity of the film does not conform to any established practice of motion-picture technique. It is not "interesting" from the viewpoint of the layman. The sequences are carefully worked out, but they show only what happens to the shell. They portray a standardized procedure demonstrating that particular division of work between the various machines which, in the considered judgment of the engineers, represents ideal educational plant machining methods. Since the most significant element involved is tool performance, the processing steps pictured are those which are dynamic in character. Concepts that are static—such as time and materials—can, naturally, be recorded to greater advantage by words and diagrams. It was believed, however, that in situations involving action—actual operation—the film would do a better job. By means of alternating long shots and full-screen close-ups, the film gives the trained observer a quick demonstration of how equipment with which he is familiar can be used to greatest advantage on a specific job. In the case of special devices to speed production, it shows not only how they are constructed (this could be done equally well by means of still pictures or mechanical drawings), but also how they are applied to the process at their appointed time. In other words, the picture brings out all operating details in proper relation to one another—no step, no device is torn from its context.

The value of this method of presentation is obvious. From the very beginning to the final step of packing for shipment to the arsenal, the spectator never loses sight of the shell forging in process. In the meantime, the various sequences emphasize the all-important factor of speed. It is understood, of course, that many of the operation intervals are further reduced in the General Railway Signal Company's proposed layout for quantity production.

The film was recently projected for a group including Maj. Gen. C. M. Wesson, Chief of Ordnance. All expressed approval and commendation. It appears certain that the picture represents a valuable service and short cut not previously applied to ordnance manufacture. In this field, at least, it exemplifies a new means of communication. By visualizing the essence of the General Railway Signal Company's experience in machining 75-mm. shell, it should immediately benefit both the Government and other processors of this shell. It is, consequently, an interesting question whether any ordnance process involving combined machine work and manual dexterity does not require such audio-visual clarification for maximum efficiency.

On the strength of the experience with the General Railway Signal film, it is safe to say that the cost of such sound-and-color motion pictures is low compared with the potential savings involved. And assuming that the anticipated effectiveness of this particular picture is actually realized in use, it would seem extremely worth while to maintain a permanent file of production-analysis films covering all regularly required materials. With these action records of production once made and kept up to date as processes are modified or improved, the Ordnance Department could ostensibly place contracts with any manufacturer anywhere, at any time, with greater assurance of prompt, efficient, and economical execution.

ARMY ORDNANCE

Founded 1920

Published Bimonthly by
THE ARMY ORDNANCE ASSOCIATION
WASHINGTON, D. C.

Col. J. L. Walsh, Founder and Editor, 1920-1922
Brig. Gen. R. H. Somers, Editor, 1922-1925
Brig. Gen. R. L. Maxwell, Editor, 1925-1926
Col. C. R. Baxter, Editor, 1926-1929

Editor: Lieut. Col. L. A. Codd, Ord. Res.
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JANUARY-FEBRUARY, 1942

Month by Month

COINCIDENT WITH THE DECLARATION OF THE state of war thrust upon the United States by the rulers of Japan, Germany and Italy came other declarations looking to the maximum use of all the resources of our country for the war effort. Notable among these was the statement of the Supply, Priorities, and Allocations Board, and leaders of labor and management. The board, the supreme policy-making agency in the war-production drive, declared: "From now on, every action by this board and by the related civilian agencies of the Government must be keyed to one goal—complete victory in this war which has been thrust upon us . . . production schedules for all manner of military items must be stepped up at once. Every activity of our national life and our civilian economy must be immediately adjusted to that change. To attain victory, we aim at the greatest production which is physically possible; we call for the closest national effort that can possibly be made. This policy applies all down the line—in the agencies of Government, in industry, in agriculture, in commerce, in labor, in every phase of national life. There is but one standard for activities in all of these fields—the simple question, 'Is this the utmost that can be done to bring victory?' Policies and actions which meet that test must be adopted; those which do not must be rejected."

At the same time, leaders in industry and labor pledged full support not only for the arms-production program but for whatever might be needed to bring about victory. "All internal differences in the labor movement," said one spokesman, "all differences between labor and management must be subordinated to the common need."

What the victory program will actually be is unknown at this writing (December 8, 1941). In the first 18 months of the present defense program, national expenditures have totaled approximately $15,000,000,000. At the end of 1941, the monthly rate of expenditure approached $2,000,000,000. New plans, it is said, will virtually double all present production schedules, including airplanes, tanks, and guns, with special emphasis on long-range 4-engined bombers capable of operations far at sea and of carrying the war to distant points. It is understood that the naval building program also will be speeded up materially, especially in view of reports of severe capital losses by first Japanese attacks.

Commitments averaging $43,000,000 daily were made by the Army Ordnance Department during the month of October. The total for the month was $1,355,642,753—the largest amount for armament orders which had been placed by the Department during any month in the present emergency. On June 30, 1941, the President approved the regular 1942 appropriation allocating $292,400,000 for the Ordnance Department. An additional $2,889,000,000 for Ordnance was approved August 25, 1941. Nine weeks later, the Department had made commitments for these funds with the exception of some $500,000,000 for which contract negotiations were practically completed. The speed with which commitments have been made was due to the fact that plans for these expenditures—both in regard to the items to be procured and the industrial producers selected to manufacture them—had been made well in advance under the procurement program of the Ordnance Department.

ON THE VERY DAY OF THE DECLARATION OF a state of war, the Army Ordnance Department unveiled its latest development—the 57-ton tank known as the T1E1. Designed by the Ordnance Department in conjunction with the best automotive engineering skill of private industry, the new tank is the first of a fleet of fifty such vehicles to be built by the Baldwin Locomotive Company for the Army. Requiring a crew of six or seven men, depending upon its mission, the new weapon has the greatest concentration of fire power of any tank yet produced in this country.

Brig. Gen. G. M. Barnes, in charge of engineering in the Ordnance Department, accepted the vehicle from the Baldwin Company on behalf of the Chief of Ordnance. "Today's occasion," General Barnes said, "takes on added importance and significance in view of the declaration of war by Japan against the United States. This great fighting vehicle exceeds all others in its military characteristics. It represents but one of the many new and previously unheard of weapons of modern warfare which are being added day by day to the military equipment of our Army."

The new heavy tank is not only a symbol of the growing military might of the United States; it is also good assurance to all our people that in engineering skill and manufacturing knowledge the Ordnance Department and industry are producing newer types of vehicles which will assure leadership to our fighting forces. Elsewhere in this issue, Maj. Gen. C. M. Wesson, Chief of Ordnance, outlines some of the principal developments in the leading categories of ordnance. Now that war has come to us, it is to be hoped that critics of ordnance progress will devote their energies to helping

get the job done rather than to delaying it by criticisms which until now have been generally unwarranted. That sort of thing was understandable while we were at peace. Now that we are at war the prospect is far too serious and the implications too dreadful for ill-considered or ill-informed journalism.

THE LATEST COMPREHENSIVE ANALYSIS OF defense production was given by William S. Knudsen, Director General, Office of Production Management, on December 3, 1941, in an address before the National Association of Manufacturers. The salient points were:

"The over-all picture today is about as follows on facilities: We have committed about $4,578,000,000 worth. This includes all the facilities ordered by the Army, Navy, and Maritime Commission. We have delivered to the defense program $850,000,000 worth of machine tools in 1941, and expect to deliver $1,200,000,000 worth in 1942. The final picture isn't quite ready yet, but in 1942 I think the major part will be behind us. The ratio of $4,600,000,000 to $43,000,000,000 isn't too bad if we get the proper production out of it. The expanse in the contract-distribution service will be a welcome adjunct to the production program. The shortage created by priorities has given a good impetus to the contract-distribution service program.

"Summing up the production picture from the foregoing, it can be stated perhaps as follows: Production of every item in the defense program is on the way. You know I cannot quote these quantities to you, but I will try to give you an idea this way: Contracts are placed of a total value of $43,000,000,000. Deliveries as measured by disbursements will amount to $12,700,000,000 to January 1st. The calendar year 1942 should show $26,000,000,000 of products shipped; in 1943, we hope to produce $36,000,000,000 of products. Subcontracts for the month of October, according to the Contract Distribution Division, amounted to $188,000,000. This, of course, is only a small fraction. The majority of subcontracts are placed by the contractor himself.

"As for the position of the defense program on planes, tanks, guns and ammunition, and ships, the standing as of January 1st will be: planes, 60 per cent of peak; tanks, 30 per cent of peak; guns and ammunition, 50 per cent, and ships, 40 per cent.

"Work has gone along somewhat better in the last few months. A new plant for building bombers will be opened in Kansas City early in January, and three more plants will be finished late in 1942. With these four plants and our present capacity, we ought to have around a capacity of 800 heavy bombers a month. On tanks, we have made some progress in work now. They will reach 2,800 a month by the end of 1942. Guns of smaller size are progressing, and ample facilities have been provided.

"Ammunition at first was stymied by the lack of explosives. Satisfactory progress has been made both in powder and TNT. We are assured of a satisfactory supply by January 1st. In shipbuilding, great advance has been made through the progress of welding which, incidentally, will be used in tanks also during this coming year. A monthly output of 400,000 to 500,000 tons cargo capacity of ships wouldn't seem unreasonable for 1942."

On the subject of defense strikes Mr. Knudsen said: "On labor, we have had a difficult period, also, with production generally on the up grade. We know of the strike troubles that culminated in the coal strikes last month. In most cases, wages and working conditions were not the issue, but the usual demands are for closed shops, union shops, preferential shops—whatever you call them. I can't for the life of me understand how in a period of national emergency such foolishness as this can go on. We are in a very good position regarding wages and working conditions. We have all kinds of work to do, and then we have to stop and argue about the jurisdictional disputes, and organizational disputes, and God knows what.

"I don't want to be severe with labor; I have dealt with them all my life; I have been one of them. I have up to now supported the contention that laws were not needed to get top production in the United States, and I am quite frank to confess that with our house on fire, we can't have a strike in the fire department and refer the dispute to conciliation. If strikes can't be stopped during a period of emergency in any other way than by law, it should stop them. A friend said to me, 'What if the law doesn't stop the strike?' My answer is, 'At least put the strike in its proper position both from the standpoint of emergency and the public.'"

SPECIAL MENTION MUST BE MADE OF ONE OF the most timely books to come from the press in recent months. Its title is "Automatic Arms—Their History, Development, and Use." The authors are Capt. Melvin M. Johnson, Jr., U. S. Marine Corps Reserve, and Charles T. Haven. Captain Johnson is well known as the inventor of the Johnson semiautomatic rifle; Mr. Haven is coauthor of "A History of the Colt Revolver," a monumental work which attracted favorable notice several years ago. ARMY ORDNANCE will review this new volume in its next issue. The purpose now is to compliment the authors for a painstaking contribution to the literature on a vitally important subject.

The whole trend of modern arms is toward the automatic types. This is so with reference to the smallest weapons as well as the largest. The generation of Americans now face to face with war is also face to face with automatic arms. The proficiency of that generation in the use of these weapons will be in direct ratio to its understanding of their genesis, development, present state, and future probabilities. Every American will be a more valuable adjunct to the national defense as he understands the equipment with which the fighting forces are armed and which the civilian component eventually may come to know on most intimate terms.

The authors of this timely volume write with authority on machine guns, machine rifles, machine pistols, and submachine guns. They also discuss pocket pistols, shotguns, sporting and military rifles. The latter group are technically semiautomatic weapons. The authors go back to the beginnings of automatic arms and describe what types were tried and how they were used. They give their views on the benefits and drawbacks of each type. They describe the types now in use and tell how that type may be employed to best advantage. They also explain the design factors involved.

There can be no doubt that a distinct service has been rendered the great pressing responsibility of the moment by the authors of this book who are so well qualified to inform their fellow citizens on a subject which by stark circumstance will become more popular.

For Victory

An Editorial

THE state of war in which we now find ourselves reveals our whole people united for victory. Unity of purpose in war is the measure of ability to win. We are now engaged in righting wrongs that have been committed against us in Hawaii, the Philippines, and our other possessions in the Pacific. Evidences of this will to win are apparent in all walks of life but in none more than among that vast group of military and industrial workers who are now engaged upon the production of military armament. Our guns, our powder, the armament of our ships at sea and in the air, the weapons of our soldiers and sailors now, by general consent, are the first concern of a united nation. Ordnance, only a few years ago the least of our popular worries, now becomes an urgent concern shared by all our people.

The military component of the ordnance effort in our Army is especially well prepared for its job. Guiding that effort as Chief of Ordnance is a man whose energy, experience, vision, and judgment give confidence and spirit to the vast enterprise. He is assisted by a corps of officers, the caliber of whom, by and large, is unsurpassed in any army anywhere. He has at one hand a corps of soldiers comprising a highly trained aggregation of specialists upon whom the armament maintenance and supply functions of the Army have been placed with stimulating assurance. He has at the other hand a loyal group of trained civilians, many of whom have carried through the years the heavy responsibilities of the engineering and technical advancements which are characteristic of our latest matériel.

In the field of operations there are, first, our manufacturing arsenals—long since keyed to maximum production of their particular products. These arsenals have not only led the way in arms production but have furnished a nucleus of engineers and technicians for the training of industry in the unknown tasks of arms production. Then there are the proving grounds, the laboratories, and the vast supply lines of depots and stations for the storage and issue of fighting equipment to our troops. These are far-flung stations, indeed, and embrace facilities of great magnitude, many of which have just come into operation, while others are still building. Finally, there is the great training center at Aberdeen where officers and soldiers are taught the technique of ordnance maintenance.

Hostilities between the United States and Japan, begun December 7, 1941, find the Ordnance Department of the United States Army at a degree of efficiency and of facility the like of which has never before existed in the history of our country. But its task grows daily in volume and complexity. Our war effort in this field will mean an intensification of the work of that vast organization to the maximum of the ability of every individual comprising it.

The industrial prospect of the Ordnance responsibility is equally encouraging. The tremendous program of arms production begun in September 1940 had progressed through nearly fifteen months before hostilities began. That program had been planned over many years and is being executed according to plan. Utilizing the principle of decentralized operation which had marked Ordnance endeavor since the World War, the huge requirements of September 1940 for arms, ammunition, fighting vehicles, and every category of ordnance equipment had been apportioned to private industry or to new plants in specialized categories which were promptly begun. The Ordnance District system has functioned with remarkable efficiency and is largely responsible for the encouraging results thus far obtained.

Among the thousands of private industrial companies now engaged in ordnance production, the same spirit of determination is characteristic. Plants, large and small, in every locality in most of the forty-eight states of the Union, are producing finished articles or components of finished articles contributing to the growing needs of our fighting forces and those of countries friendly to us.

BUT the tempo now increases. Harder work, longer hours, and greater production must be the rule. The Under Secretary of War sounded the keynote the day war was declared: "It is essential that our procurement be put into highest gear at once. All steps must be taken to increase the speed with which contracts are let, and to speed up maximum production of munitions. All officers and civilian employees are to be required to work as many additional hours each day as is necessary to get the day's work done. . . . You are directed to take all necessary steps to boost munitions manufacture to the highest possible level. Additional overtime work and second and third shifts must be arranged. Our production must be put on a 24-hour-a-day basis. You are directed to take such steps as will achieve this as quickly as possible."

In bringing about compliance with these orders, all hands will turn to instantly. Profits must not be the norm of our production. Hours of labor can no longer be the gauge of our work. War is no 9 to 4:30 job—if we insist on keeping it so we will lose it! That goes all down the line—for Mr. Big and for Mr. Little. Furthermore, to stop arms production for any reason whatsoever will be treason, and no American worthy of the name will engage in any activities which would delay arms production for an instant.

ARMY ORDNANCE is the voice of a nation-wide society of more than 10,000 American citizens who, since the last World War, have tried to prepare themselves to meet the responsibilities of today. It should be unnecessary, therefore, to restate in this place the readiness and willingness of each member of the society and of all he represents to assist in every possible way the complete and final victory of our armed forces. The society as a unit, through its various local chapters, its officers, and its members everywhere, stands ready to serve so that the American fighting forces, technically and tactically, may have the most of the best armament at all times.

The Army Ordnance Association twenty-two years ago was dedicated to the proposition, "Industrial preparedness for war as our strongest guaranty of peace." Now it must temporarily lay aside that device to be resumed again in calmer days. Along with all the might and power of the United States, the determination of all our fellow citizens and especially the facilities of industrial America, we now dedicate ourselves: "For victory—regardless of our lives, our liberties, and our pursuits of happiness." The Ordnance fraternity in the United States stands for no less than that and for everything more that may be required. L. A. C.

Association Affairs

HARTFORD-SPRINGFIELD POST

THE Hartford-Springfield Post, the eighteenth local chapter of the Army Ordnance Association, was established at an inaugural meeting and dinner November 18, 1941. The guest of honor and principal speaker at the ceremonies was Maj. Gen. C. M. Wesson, Chief of Ordnance, U. S. Army. Col. Frederick H. Payne, vice-president of the Association and chief of the Hartford Ordnance District, presided at the meeting and dinner which were held at the Hotel Bond, Hartford, Conn. Nearly 700 members and guests were in attendance. General Wesson's address is published as the leading article in this issue (page 537). Addresses were also made by Lieut. Col. W. S. Broberg, executive officer, Hartford Ordnance District; Hon. T. J. Spellacy, mayor of Hartford, and Lieut. Col. L. A. Codd, executive vice-president, Army Ordnance Association.

John C. Garand, inventor of the Army's semiautomatic rifle, was presented the Association's Brig. Gen. John H. Rice Gold Medal for leadership in ordnance engineering. Mr. Garand was chosen by the Committee on Awards consisting of Col. Wm. W. Coleman, chairman, and Messrs. August H. Tuechter and Earl B. Gilmore, members. The actual presentation of the medal was made by General Wesson after the following remarks and reading of the citation by Colonel Payne:

"The Rice Medal was awarded several months ago to Mr. John C. Garand of the Springfield Armory, pioneer in the development of the semiautomatic shoulder rifle which popularly is known as 'The Garand.' We have saved the actual presentation of the medal for this fitting occasion. The long and arduous road to the successful development of the semiautomatic shoulder rifle, M1, was begun by Mr. Garand in 1919. It reached its last stage in 1929 when the construction of the first caliber .30 Garand was authorized. This model was tested at the Aberdeen Proving Ground in 1931; subsequent modifications and tests lasted until 1935, and final changes, revisions, and tests were satisfactorily completed in December of that year. In January 1936, the rifle was officially standardized as the U. S. Rifle Caliber .30, M1. The first delivery of production weapons started at Springfield Armory during September 1937 at the rate of ten rifles a day. By January 1940, the rate was 200 rifles a day. Recently, the rate reached 1,000 a day. Following is the citation which accompanies the award of the Rice Medal to Mr. Garand.

"'The Army Ordnance Association acclaims this inventor for his ability, ingenuity, and perseverance in developing against severe competition a semiautomatic rifle for the American Army. The Association honors him with its medal bearing the name of another distinguished Ordnance engineer, the late Brig. Gen. John H. Rice, who himself had an important part in the early steps toward the adoption of a semiautomatic shoulder piece shortly after the World War.'"

The Hartford-Springfield Post, which embraces the state of Connecticut and the four western counties of Massachusetts, was begun by an organizing committee consisting of Colonel Payne, Col. James D. Skinner, Bridgeport; James R. White, Norwalk, and the late Kent Hubbard, Hartford. The newly elected officers are—president: Colonel Payne; vice-president: C. H. Granger, Waterbury; directors: E. T. Bullard, Bridgeport; H. C. Beaver, Holyoke; E. B. Gallaher, Norwalk; C. F. Hoke, Springfield; secretary-treasurer: Colonel Broberg. The charter of the new Post as issued by the Army Ordnance Association, was presented by Colonel Codd on behalf of Brig. Gen. Benedict Crowell, president. In introducing General Wesson, Colonel Payne said:

"Now it is my pleasure to introduce to you our guest of honor, General Wesson, as our principal speaker this evening. He does us exceptional honor by coming to us this evening despite the great responsibilities that are his in Washington. Before I ask him to speak to us, I want to give him, on your behalf, our deep assurances of our heartiest support. We know as well as any other group in the United States, and far better than some others, what a magnificent job he is doing as Chief of Ordnance of our Army. He has the utmost confidence of the engineering profession, he has the finest coöperation from American industry as a whole, and the work he and his Department are doing in every branch of ordnance engineering and production is historic in every sense of the word. It is your honor and mine to serve with this outstanding officer."

MEMBERSHIP of the Army Ordnance Association during 1941 reached numerical strength never before attained during the twenty-two years of the society's history. The all-time high as of December 1, 1941, was 10,240. This represented a steady monthly total increase: January, 171; February, 196; March, 337; April, 313; May, 275; June, 267; July, 317; August, 246; September, 240; October, 299; November, 287.

The membership, spread through forty-eight states and wherever the American flag is flown, includes eighteen local chapters. The objective: a constantly growing membership of American citizens pledged to industrial preparedness for war as our nation's strongest guaranty of peace. The objective was stated in these words in 1919. It has been persistently upheld against all odds. Victory—complete, absolute, final—is now its immediate purpose.

Colonel Broberg's address, which was of special timeliness, follows in part:

"The Hartford Ordnance District comprises the smallest of the thirteen Ordnance districts in the United States, for it includes only the western half of Massachusetts and the State of Connecticut. Nevertheless, the Ordnance Department has placed here 310 prime contracts with 82 contractors, and 2,432 subcontracts in 461 plants, not to mention possibly a thousand or more subcontracts from Ordnance prime contractors elsewhere. Alone, the total value of the prime contracts for which our district is responsible amounts to the staggering sum of $355,335,756.

"It is difficult to estimate the cost of our subcontracts because these have been placed here by sources outside the district, but it is assumed that approximately $60,000,000 worth of work may be added to the above sum, making a total of $415,000,000 as the value of ordnance matériel now being manufactured in this area. We have written 200 contracts in our office since July 15th, totaling $217,067,767, and we have received for administration from arsenals and Washington contracts amounting to $69,443,000, making a total of $286,000,000 in new prime contracts placed here since July 15th. The Hartford Ordnance District Office has, therefore, averaged $2,700,000 a day during the past four months.

"From the money-value standpoint, the Hartford Ordnance District ranks among the first three in the country; in the number of items produced, we naturally are far in the lead, for it takes a lot of fuzes to equal the price of a tank and a lot of small-arms ammunition to equal an artillery carriage. In fact, without expansion, today we are delivering more small-arms cartridges a week than the maximum monthly production during the World War. Cartridge-case producers are so far ahead of schedule that we have had to divert them temporarily to other defense orders. Our machine-gun program is right on time in some plants and ahead of schedule in others. The same may be

said for fuzes, data-transmission systems, fire-control equipment, artillery-carriage and tank accessories, antiaircraft carriages, and many other items.

"I am pleased to exhibit the ten thousandth machine gun presented by the High Standard Manufacturing Company on the first anniversary of the signing of its contract. It represents a remarkable achievement which is being duplicated in other fields of national-defense production here in New England. Bridgeport Brass Company recently delivered its twenty-five millionth cartridge case and Worthington Pump its first battery of 90-mm. antiaircraft carriages, to mention only two. Production on the Garand rifle is increasing every day to supplement the marvelous production now being accomplished at Springfield Armory.

"It gives me great pleasure to assure my chief that our production schedules will all be met if it is humanly possible for us to do so. With our manufacturers, I take pride in assuring you of good workmanship. Our products may not all be as shiny as the exhibits displayed here, but they never have failed—and they never shall fail—to pass final inspection.

"Each war emergency has brought a change in the industrial map of the United States. The present emergency is no exception, and there is a decided relocation of industry in the making right now. Due to the tremendous size of the present program and the urgent necessity for production, conversion and expansion of existing facilities and construction of new ones are in progress. Expansion and new construction are approved only where there is no existing capacity. In spite of our big share in this program, I firmly believe we can create more capacity here with present equipment—plus a dash of the well-publicized Yankee ingenuity. Now is the opportunity for that trait to make itself apparent. Except for a few arms manufacturers who are loaded with work, all others face the same problems and the same risks and the same troubles in converting their plants to ordnance production.

"These are the days when Yankee conservatism must make way for a little pioneer spirit. Conservatism is an admirable trait; it may even be the foundation of New England's industrial success. It might be presumptuous for me to criticize it were it not for the fact that it is probably the main cause for failure of some of our manufacturers to dive into this national-defense effort. They are not many, but they are important. It is almost a reflection on our courage when no bids can be obtained from this district, which results in awards being made elsewhere to less-qualified bidders who assume the risk of performance—and calmly subcontract the whole job back to New England. Although subcontracting is the order of the day, I still feel that the man who assumes the greater part of the production should also assume the responsibility for the prime contract. This applies particularly to the small manufacturers."

THE ORDNANCE ENDOWMENT, a fund to perpetuate the ideals of the Army Ordnance Association for the industrial preparedness of the United States, was announced in the last issue of ARMY ORDNANCE. *The Endowment Committee, under the chairmanship of Mr. T. M. Girdler, Cleveland, Ohio, consists of seventy-two industrial leaders representing all branches of ordnance engineering and production. The goal of the Committee is a fund of $500,000.*

During the brief period since the foundation of the Committee, a total of $142,000 (as of December 10, 1941) has been contributed by 75 companies now engaged in armament production. The Committee will organize along regional and industrial lines early in 1942 and undertake its task for the prompt achievement of its goal. Contributions of from $1,000 to $10,000 are welcome. The American Security and Trust Company of Washington has been appointed trustee to administer the fund.

Necrology

COL. JAMES BROWNRIGG DILLARD, charter member of the Army Ordnance Association and of the Cleveland Post, died at Winton, his country place near Clifford, Va., September 28, 1941. He was a director of the Cleveland Twist Drill Company, Cleveland, Ohio. His long service both to the Ordnance Department as an officer in the Regular Army and to industry had won for him a large acquaintance in both fields of endeavor.

Born at Norfolk, Va., April 22, 1882, Colonel Dillard attended Tulane University which he left to enter the United States Military Academy. He was graduated a member of the class of 1904. Shortly after graduation he began his service in the Ordnance Department and soon was identified with many of the armament-engineering developments of our Army. He served in the Office of the Chief of Ordnance and at the several manufacturing arsenals. He became head of the Engineering Division, Office of the Chief of Ordnance, during the World War, succeeding the late Brig. Gen. John H. Rice in that office. For his World War service, both in this country and abroad, he was awarded the Distinguished Service Medal.

Colonel Dillard resigned his commission in the Army April 2, 1920, to become associated with the Cleveland Twist Drill Company as general superintendent. This office he held for many years and had been a director of the company for some ten years prior to his death. His passing removes from the Ordnance scene another officer whose engineering service during the World War was of great import both during that conflict and in the years which followed. Although his business activities in recent years required much of his time and attention, Colonel Dillard's loyalty to the Ordnance cause never abated. He was a zealous advocate of the Army Ordnance Association and its work since its formation. His encouragement and help will be missed greatly by his Ordnance associates who were privileged to work with him through the years.

AUGUST H. MORAN, head of the legal section, Fiscal Division, Office of the Chief of Ordnance, died suddenly October 18, 1941. He was a charter member of the Army Ordnance Association and a member of the Washington Post.

A native of Buffalo, N. Y., Mr. Moran came to Washington in 1919 on the staff of the Arsenal Orders Branch, Office of the Chief of Ordnance. He was educated at Cornell University and George Washington University. After leaving the Ordnance Department in 1922 he entered the private practice of law in Washington. He was a former vice-president of the local Cornell Club and a member of several honorary legal organizations.

When the present Ordnance program was undertaken last year, Mr. Moran was recalled to service in the Ordnance Office as legal advisor and was engaged in this work at the time of his death. He was active in affairs of the District Bar Association, taught civil procedure for several years at Southeastern School of Law, and coached hundreds of law students for District of Columbia bar examinations. In addition to an unusual talent, he was possessed of a kindly disposition which won for him many friends in various fields for whom his death is a real loss.

NOTICE also has been received of the death of the following members of the Association: Edwin H. Barker, Moylan, Pa.; Eugene C. Benington, Larchmont, N. Y.; J. Wallace Carrel, Cincinnati, Ohio; Melbert B. Cary, Jr., New York, N. Y.; E. Walfrid Ericsson, Brooklyn, N. Y.; Robert Hazel, Newark, N. J.; Otto V. Kruse, Philadelphia, Pa.; C. M. Niezer, Fort Wayne, Ind.; G. S. Salzman, Cleveland, Ohio; Charles R. Strong, Ardmore, Pa.; A. W. Tissell, Wilmington, Del.; L. E. Walsh, River Forest, Ill.

Ordnance in Review

THE MACHINE GUN—ITS EARLY APPLICATIONS, PART III

LIEUT. COL. CALVIN GODDARD

THE reason for Gatling's divided loyalties, mentioned in Part II of this series, lay presumably in the fact that though of southern origin (his birthplace was in Hertford County, N. C.), manifold commercial interests tied him to the North. He probably would have much preferred to sell his weapons to the Confederacy, but apparently a keen business sense refused to permit his sympathies in that quarter to result in neglect of opportunities elsewhere. At any rate, practically all commentators upon this gentleman's activities refer to the experimental use of his gun by Federal forces in the Civil War, noting further that the military of the day looked upon it so dubiously that in most of the minor fracases in which it figured (it does not appear to have been employed in any major affairs) it was operated by civilian representatives of the manufacturer. So when one encounters, in a volume ("Tactical Organization and Uses of the Machine Gun in the Field," 1899) by Col. John Henry Parker—to whom probably belongs, with Gatling, equal credit for making the latter's name almost a household word—the categorical statement that machine guns took no part in modern war prior to 1870, he is somewhat taken aback.

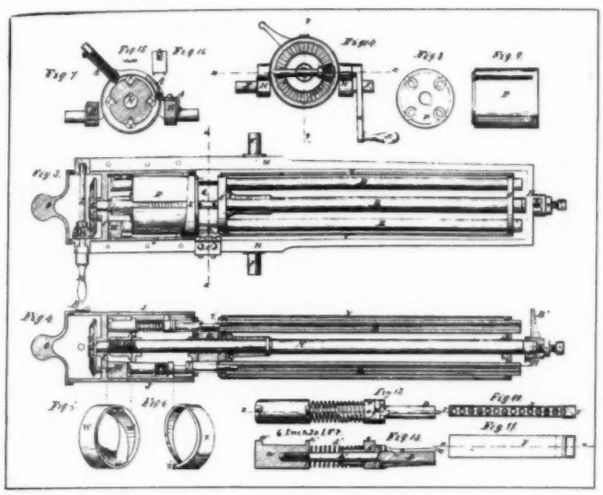

FIG. 5. DIAGRAM OF THE GATLING MACHINE GUN, FROM PATENT NO. 47631, 1865

Colonel Parker who, as a lieutenant in the Santiago campaign of 1898, earned for his weapon a bright place in America's military sun and for himself the sobriquet, "Machine Gun Parker," may have been less than thorough in his early historical researches, but no one may fairly criticize the thoroughness of the lessons in the tactics and technique of the new arm which he dispensed so earnestly on the battlefields of Cuba. These operations, however, took place in the course of a contest relatively obscure, as such are rated, and attracted none too much attention from military minds the world over. And though the Russo-Japanese War, which followed shortly, witnessed, as did lesser wars that supervened, the wider employment of the machine gun, it was not until the outbreak of the world conflict of 1914-1918 that it may be said to have come fully into its own.

From 1864 to 1898 is no brief span, and it may not be amiss to inquire just what was happening to the Gatling during that period. Obviously, if it had to wait thirty-four years after its first formal appearance upon a field of battle before gaining real acclaim from American military authorities, it must in the meantime have received nourishment from other sources if its financial sponsors were able to remain solvent. And such nourishment it did receive, for Gatling partook definitely of Sam Colt's aggressiveness as a salesman and, as we have already seen, commenced almost before his patent applications were filed to tell the whole world of his invention. The result was that he received invitations to demonstrate his piece widely throughout Europe, with an outcome in most instances more favorable than otherwise.

Perhaps the first Continental nation to evince an interest in his device was France, whose Emperor (Napoleon III) was, it will be recalled, on the lookout for some new and formidable agency wherewith to neutralize the effects, moral and material, of the terrible Prussian needle gun. So when, in October 1863, Gatling wrote describing his piece to Major Maldon of the Committee on Artillery for the French Ministry of War, he received a reply full of requests for additional information, coupled with an inquiry as to whether it would be possible to send to France a specimen weapon together with enough ammunition for the conduct of conclusive trials. The immediate further exchange of correspondence led to no definite action on the part of the French Government, and a ban on all exports of munitions, established soon after by the U. S. authorities, scotched the whole matter for the time being.

However, when Napoleon III saw, at the Paris Universal Exposition of 1867, a specimen of Gatling's product, he ordered it withdrawn from exhibition and sent to Versailles, where it was tested in his presence. But despite the fact that it presumably embodied the improvements incorporated in the second U. S. patent (1865), its performance was not sufficiently impressive to cause him to supplant with it the Montigny type of mitrailleuse already adopted and acquired to the number of 190 pieces by the date of declaration of war with Germany three years later.

Napoleon III did, however, order the purchase of several specimens of the Gatling, which were in the hands of General Chanzy's troops during certain of the active operations in which these were engaged and, in addition, purchased a number of Claxtons, a contemporary weapon of which but meager descriptions appear to survive today. We find no entry covering it in either British or American patent files, nor does the name figure in connection with any type of weapon in the U. S. "Official Records." The most copious reference to it so far discovered, appears in Fosbery's paper (see Part I) and reads as follows:

"The next in order is the mitrailleur Claxton, also the invention of an American. On this weapon I was lately requested to report for the information of Her Majesty's Government, and having carefully examined the mitrailleur itself, its ammunition, and accessories, I am unable to speak of it much more highly than of the Agar [Ager]. It consists of a revolving framework carrying six or eight rifled barrels, any pair of which may be readily adjusted in front of two sliding breech actions, thus forming for the time being two breech-loading rifles placed side by side. A species of pump handle placed between them is worked by one soldier, whilst another feeds them with cartridges, and the rapidity of the fire is limited by the physical ability of the soldier to work this handle.

"The machine is feeble in construction, slow in action, furnished with ill-conceived projectiles, and mounted on a carriage which a week's service would destroy. The firer is protected, however, by an ingenious shield, and seated on the trail in a way which gives him a good position for the service of the weapon. Although in its present state this mitrailleur is undeserving of much attention, there are several things about it worth noticing by those who would thoroughly study the whole subject. Its rate of fire is about 80-90 shots per minute, and it is made in two sizes, the larger throwing ½-pound projectiles, the smaller, the Chassepot bullet."

(To be continued.)

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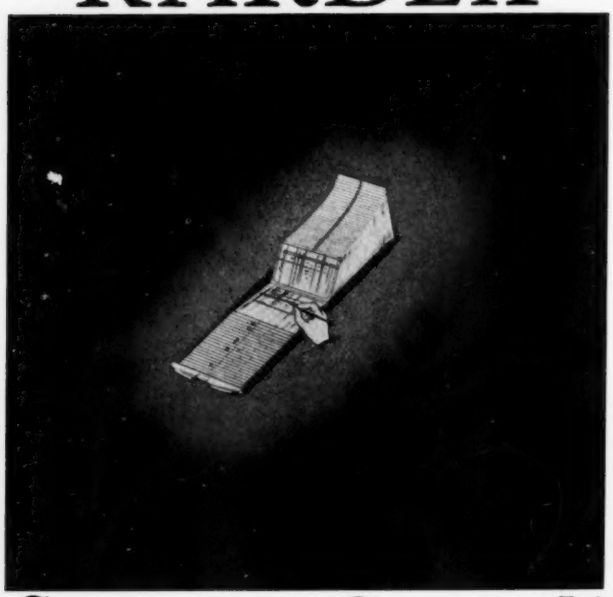

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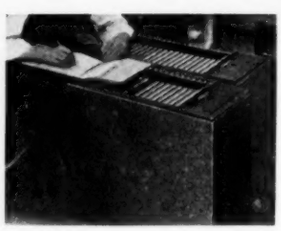

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THE ORDNANCE SHOP, FORT ORD, CALIF.

LIEUT. ROBERT E. PETERS, 3RD ORDNANCE BATTALION

DESIGNED and constructed to house the most modern in facilities for the inspection and maintenance of ordnance equipment in the hands of troop units, the III Army Corps ordnance shop at Fort Ord, Calif., was constructed at a cost slightly in excess of $93,000. To say that the shop is adequate would hardly be descriptive, for it is the most modern and best equipped ordnance shop operated by the tactical forces in the United States.

TECH. SGT. SAM WARREN, GUIDING SPIRIT OF THE III ARMY CORPS ORDNANCE SHOP

The shop building comprises over 14,000 square feet of floor space and is of steel and concrete construction with a large window area and skylights. The central section is approximately thirty feet high by thirty-two feet wide and contains a traveling 10-ton crane which runs the full length of the building. This is a necessity in view of the fact that tanks and large-caliber guns and howitzers have to be maintained. Large doors along each side and at each end provide easy access to any part of the building. Adequate heating is obtained from four gas furnaces placed at the corners of the building.

The Corps Ordnance Service is charged with the responsibility of maintaining and repairing all ordnance equipment in the hands of troop units permanently or temporarily stationed at Fort Ord and vicinity. To create an efficient method for handling the vast quantity of work involved in this maintenance, the ordnance shop is divided into sections, each a small shop in itself. Included are a machine shop to handle all types of machine work, a carpenter shop, a small-arms repair shop to service and repair pistols, rifles, and machine guns, an artillery shop for the maintenance of 37-mm. antitank guns, 75-mm. guns, and 155-mm. guns and howitzers, among others; a tool room, photographic and blueprint room, shop office, and an optical-repair shop where fire-control instruments are repaired and adjusted.

The Ordnance Department has established a reputation not only for doing all types of work, but for doing precision work,

and it is toward this end that only the best machinery was purchased. Changing conditions were realized at the time of these purchases, and consideration was given to future needs in order to make the shop as complete as possible. The machine shop at present contains a universal milling machine, a jig borer, four machine lathes ranging in capacity from 10-inch swing and 3½-foot bed to 24-inch swing and 16-foot bed; an 80-ton hydraulic press; four drilling machines of various sizes, including a 5-foot arm, 11-inch column radial drill; six grinders, including tool, bushing, and precision types; a motor-driven 6-inch by 6-inch metal saw; a 25-inch shaper; electric and oxyacetylene welding equipment; a gas-fired blacksmith forge; an oven-type heat-treating furnace; two 5-horsepower air compressors; a set of pneumatic tools; a 72-inch capacity magna-flux magnetizer-demagnetizer unit, and a Rockwell hardness tester. In the carpenter shop there is a wood lathe, a drill press, a circular saw, band saw and scroll saw, a wood shaper, a 4-inch by 18-inch surfacer, a 12-inch disk sander, and a 6-inch jointer. Each of

A LIGHT TANK READY TO BE SERVICED AT THE ORDNANCE SHOP AT FORT ORD, CALIF.

the other sections is also equipped with the necessary machinery and tools for proper functioning. To tool the shop as listed above, the approximate cost was $60,000.

The machine and carpenter shops are arranged along one side of the shop with the machinery so placed as to utilize its capacity to the best advantage. Sufficient light is provided by the large windows along the sides and by the skylights in the ceiling, but electric lighting is provided for use when necessary.

The operating personnel, furnished by the 82nd Ordnance Company, is composed for the most part of selectees supervised by Regular Army men and a few civilians. A number of the operators were trained machinists when inducted into the service, and the rest were trained at the Ordnance School, Aberdeen, Md., or at other schools conducted by the III Army Corps. Additional personnel are continually being trained at the shop itself under the careful supervision of the trained operators. (EDITOR'S NOTE.—An article by Brig. Gen. Julian S. Hatcher on page 565 of this issue outlines the work being done by the Ordnance Training Center at Aberdeen, Md.)

With the finest in building constructions, the best in modern machinery, and with the personnel becoming more skilled each day, the troops receiving maintenance and repairs at the Fort Ord ordnance shop will be kept at the peak of fighting efficiency in so far as their ordnance equipment is concerned.

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Professional Digest

Defense Inventions

Edwin F. Bicknell*

IT was recognized, in the early stages of the European conflict, that the United States must utilize new ideas as well as men, materials, and machines, in all-out defense effort. Accomplishment of this necessitated the establishment of an adequate service for speedily handling to the greatest advantage inventions which might be submitted and might prove of untold value to the nation's welfare.

The National Inventors Council of the Department of Commerce was formed as a central Government clearing house to receive inventions and suggestions that might prove of value to the national defense and thereby insure that each and every inventor or proposer of an invention or idea should receive the most expert and sympathetic attention. The Council was formed in August 1940, by the Secretary of Commerce with the approval of the President of the United States.

Dr. Charles F. Kettering, chairman of General Motors Research Corporation, was selected as chairman of the Council, with Dr. Thomas Midgley, Jr., vice-president of the Ethyl Gasoline Corporation, as vice-chairman, and Mr. Lawrence Langner as secretary.

Rear Adm. Harold G. Bowen represents the United States Navy, and Brig. Gen. Earl McFarland, the United States Army on the Council. In addition to the above men, the membership comprises outstanding American inventors, scientists, industrialists, and Government officials, all of whom are experts in their respective fields and who have had wide experience in the development and utilization of inventions. They are: Mr. George Baekeland, vice-president, Bakelite Corporation, New York; Dr. William D. Coolidge, vice-president and director of research, General Electric Company, Schenectady; Mr. Watson Davis, Science Service, Washington; Dr. Frederick M. Feiker, dean, School of Engineering, George Washington University, Washington; Dr. Webster N. Jones, director, College of Engineering, Carnegie Institute of Technology, Pittsburgh; Dr. George W. Lewis, director of aëronautical research, National Advisory Committee for Aëronautics, Washington; Dr. Fin Sparre, director, development department, Du Pont Corporation, Wilmington; Maj. Gen. W. H. Tschappat, U. S. Army (Retired), Washington; Dr. Orville Wright, director, Wright Aëronautical Laboratory, Dayton; Mr. Fred Zeder, vice-chairman of the board of directors, Chrysler Corporation, Detroit.

Hon. Conway P. Coe, United States Commissioner of Patents, is the direct Council representative of the Secretary of Commerce, and on October 7, 1940, when the President approved the Council budget, Commissioner Coe and his associates were instrumental in organizing the service staff. The high professional standing of the Council members, all of whom serve without compensation, inspires confidence in the ability of the Council to perform ably the work for which it was created.

The Council has formed twelve committees for the handling and evaluation of inventions. These committees with their chairmen are as follows: 1. Ordnance and Firearms, Maj. Gen. W. H. Tschappat; 2. Land Transportation and Armored Vehicles, Mr. Fred Zeder; 3. Aëronautics, Dr. George W. Lewis; 4. Remote Control Devices, Dr. Charles F. Kettering; 5. Instruments, Dr. William D. Coolidge; 6. Naval Warfare, Dr. G. T. Codrington; 7. Signals and Communication, Dr. William D. Coolidge; 8. Chemical and Chemical Warfare, Dr. Fin Sparre; 9. Internal

*Senior Industrial Specialist, Division of Contract Distribution, Office of Production Management. Formerly Ordnance Engineer, National Inventors Council, Department of Commerce.

Combustion Engines, Dr. C. F. Kettering; 10. Metals and Metallurgy, Dr. Webster Jones; 11. Forts, Fortifications, other Structures, and Camouflage, Dr. Frederick M. Feiker; 12. Clothing, Sanitation, Health, and Commissariat, Mr. Watson Davis.

THE Council works with the Army, Navy, and other defense agencies through liaison officers appointed by the various Government bureaus. Thus, it can be seen that the National Inventors Council is one of the cogs of the "defense gearing" of this nation and functions as an integral part of the great technical set-up of the defense program. The functions of the National Inventors Council should not be confused with those of the United States Office of Scientific Research and Development. It is for the introduction of all types of inventions that the National Inventors Council is forever on the alert, while the other bureau is interested in research and development. Both agencies perform essential duties.

The Council is especially desirous of stimulating the nation's scientists, inventors, engineers, and technicians to inventive effort in the defense field. Experience gained in the past indicates that useful suggestions are generally submitted by men having technical training as well as practical experience in one or more of the various branches of science and engineering. It is recognized, however, that valuable ideas may come from any source.

Inventions come from many sources. Letters or other communications are received from inventors in all parts of the world who are anxious to contribute to the security of the United States. Many of the inventions from abroad are presented in the languages of the country from which they come. Many inventors make personal visits to the Council offices in the Department of Commerce and discuss their suggestions with staff engineers. The armed services forward requests through proper channels for improvement of existing equipment, and the National Inventors Council has received the fullest coöperation from these branches.

Approximately 37,000 proposals have been received to date, and a sharp increase follows each new European crisis. This upward trend is even more pronounced with each world incident that affects the United States. The suggestions received cover every conceivable phase of warfare and run the gamut from a new process for the manufacture of rivets to complete designs for warships and airplanes. A fair proportion of the proposals submitted have proved to be usable. On the other hand, there are suggestions that would employ "transfer of thought" to kill an enemy, or freezing the clouds to stop an airplane invasion, or scattering lime in the sky to blind hostile pilots!

The accompanying table shows that for the past year most of the suggestions considered by the committee chairmen as worthwhile have been in the field of ordnance and firearms.

Technical Committee	*Percentage of Inventions*
1. Ordnance and Firearms	43
2. Land Transportation and Armored Vehicles	5
3. Aëronautics	8
4. Remote Control Devices	2
5. Instruments	5
6. Naval Warfare	6
7. Signals and Communications	4
8. Chemical and Chemical Warfare	3
9. Internal Combustion Engines	5
10. Metals and Metallurgy	6
11. Forts, Fortifications, other Structures, and Camouflage	5
12. Clothing, Sanitation, Health, and Commissariat	8
Total	100

The Council has formulated certain simple rules of procedure designed to protect inventors and to facilitate the handling of

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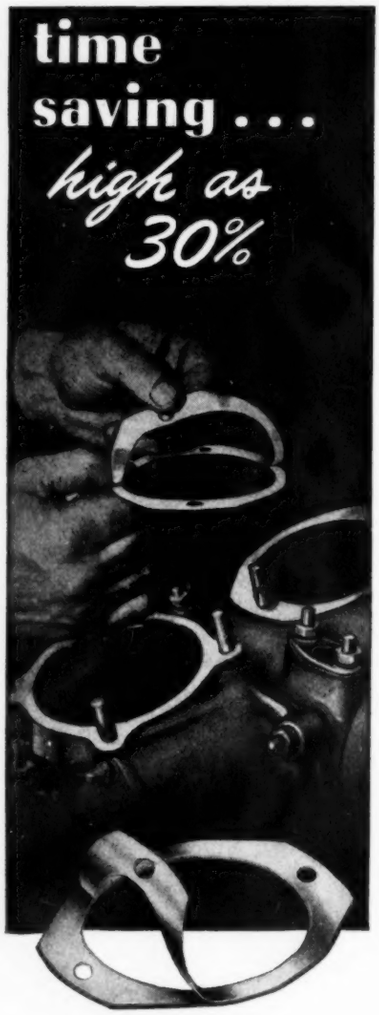

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inventions. Each suggestion, as received, is acknowledged and classified according to Patent Office procedure and is then referred to one or more staff engineers for careful examination and evaluation. The staff includes trained engineers who are specialists in the various fields, such as ordnance, chemistry, radio, aëronautics, etc., and each proposal is examined by a person well versed in that field. Proposals appearing meritorious and likely to prove useful then are referred with the comments of the engineer to the appropriate technical committee chairman for his consideration and recommendation. Occasionally, the Council discovers possible defense uses of the invention which were not visualized by the inventor himself. In some cases, the engineers suggest improvements of the original proposal.

AN invention for possible service use is considered by the engineering staff and the examining committee chairman to whom it is submitted for the three following points: (1) Does it fill any service need? (2) Is the apparatus technically sound? (3) Is the proposal sufficiently better than existing devices to justify the necessary diversion of productive capacity?

After the technical staff has considered the proposal, the committee chairman in turn examines it and gives instruction as to its disposition. Should the chairman believe the invention to be of value, he recommends that it be forwarded by the proper liaison officer to the Army or Navy, or both, or that it be sent to one of a number of other agencies such as the Office of Production Management, Office of Price Administration, Office of Scientific Research and Development, etc., for consideration and ultimate adoption if found acceptable. In cases of special merit, suggestions are presented to the Council as a whole by the individual committee chairman before the suggestion is sent to the Army or the Navy. If the Government agency to which the invention is submitted for consideration does not regard the invention with favor, the proposal is rejected and returned to the National Inventors Council with appropriate comments.

When necessary, further information is requested from the inventor. Not infrequently, he has been given the advantage of constructive criticism submitted by the armed branches of the Government and is thereby enabled to improve upon his original submission.

If the Army or Navy adopts the invention or recommends that further development work be carried on, it informs the inventor directly. In some cases, the inventors have been asked to collaborate in the development and production of the apparatus based on the invention submitted. The Council itself does not consider the question of compensation or contract between the inventor and the Army and the Navy. The negotiation of such contract is conducted by the appropriate military or naval authorities. Inventors also are informed when their proposals cannot be utilized although reasons for rejections cannot always be given.

A "library file" of the better suggestions is kept separate from the general run of rejected suggestions. This "library file" contains proposals which are not of immediate use and others that are not novel but which may be of value in the future when considered fully in the light of the ever-changing requirements for defense. Cases in the "library file" are reviewed periodically and are always available to military experts. This file already has proved to be of considerable value.

INVENTORS are not encouraged to call and submit their inventions in person, but those who do so are interviewed by the expert on the subject to which the invention relates. It is the policy of the Council never to refuse an interview to those who may wish to call in person. A résumé of the interview is written by the staff expert and the inventor told he may submit his invention in writing if he so desires. If a promising invention is submitted, the proposer is invited for further interviews with one or more of the Council's military or naval liaison officers.

Should the inventor need money to further the development of his invention, the case is then definitely out of the jurisdiction of the National Inventors Council and becomes a problem for

the Army or the Navy, or both, to decide whether they will carry on the development work or whether the Office of Scientific Research and Development will be requested by the military services to carry on the work. The National Inventors Council has no funds for the development of inventions, and the solution of this problem falls primarily in the province of the Office of Scientific Research and Development. At this stage of the work, there is need for coöperation between the Office of Scientific Research and Development and the liaison officer of the National Inventors Council.

The Council can offer no statutory protection to inventors who submit proposals, since this protection can be gained only from the United States Patent Office. Inventors who feel that the submission of a disclosure to the National Inventors Council for a determination of its potential military value is inadequate are advised to file a patent application in accordance with customary procedure. The majority of inventors apparently trust the integrity and competence of the Council members and this phase of the operations is rarely questioned. If the device subsequently proves of importance to the armed services, they usually suggest to the inventor that he file a patent application in order that the determination of the respective rights of inventor and user may be ascertained.

Each of the respective Government departments has its own method of dealing with the question of compensation. The question of compensation, however, can be considered only after tender of the suggestion or invention and its adoption by an executive department of the Government. The creation of this Council does not in any way affect the existing laws of practice as to such compensation, nor is the Council equipped to give advice to inventors on this subject.

Thus the primary function of the National Inventors Council is the consideration and evaluation of all inventive contributions to the defense effort. Each proposal, no matter how radical in conception or hasty in preparation, is carefully examined to determine its potential merits, both for the uses suggested by the inventor and for possible adaptations to defense material not contemplated by him. This examination is carried out by trained engineers who are unprejudiced in appraisal and alert for improvements.

It is to this organization that the patriotic inventor, eager to assist in the defense effort, should turn, and he will be assured of courteous attention and a competent determination of the merits of his contribution.

New Army Ordnance Depots

THE new Ordnance Department storage depots are being erected to receive the flow of munitions coming from the new plants as well as from private industry and from the Army's manufacturing arsenals.

Ammunition is now being stored at the following new facilities: Wingate Ordnance Depot, Fort Wingate, N. Mex.; Anniston Ordnance Depot, Anniston, Ala.; Umatilla Ordnance Depot, Hermiston, Oreg., and Ravenna Ordnance Depot, Ravenna, Ohio. In addition to these depots, the following new Ordnance Department storage facilities are under construction: Seneca Ordnance Depot, near Kendaia, N. Y.; Red River Ordnance Depot, New Boston, Tex.; Milan Ordnance Depot, Milan, Tenn. and San Jacinto Ordnance Depot, Houston, Tex. Two additional depots will be constructed in the vicinities of Richmond, Ky., and Charles Town, W. Va.

The structures built on the new depot reservations include above-ground storage magazines, some of them made of steel, wood, and tile; others of these structures include concrete "igloos" covered with earth. The new depots are located at a distance from large centers of population. In addition to storing ammunition some of the depots will serve as transshipping points for munitions.

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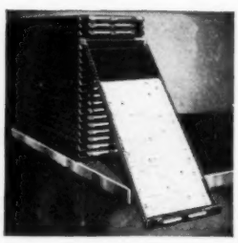

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Ordnance Personnel

ORDNANCE TRAINING CENTER

BRIG. GEN. JULIAN S. HATCHER, commanding general, the Ordnance Training Center, Aberdeen, Md., has announced the completion of courses at the Ordnance School by eighty-seven officer students. The students and courses completed are as follows:

Aviation Ordnance.—1st Lieuts. Edward C. Bergen, John F. Chick, Kenneth G. Emery, Andrew H. Frazer, Jack K. Gall, Edward D. Gilmer, Charles W. Hart, Edwin C. Heikkila, James A. Kelley, Gordon K. Mayhew, Albert S. McKaig, Jr., Robert R. Milner, Samuel W. Parnelle, Jr., Roy E. Rayle, Jr., Norman W. Reed, Herman C. Schumacher, Theodore Taube, Charles W. Thomas, Benjamin Thompson, and John F. Williams; 2nd Lieuts. Robert G. Bennett, Frank W. Brey, John S. Burt, Woodrow G. Frailing, Allen F. Jones, Henry C. Logan, Fred C. Miller, Forrest L. Romine, Robert W. Roose, George G. Shrive, Jr., Paul L. Sladek, and Walter L. Wheaton.

Ammunition.—Capt. Clinton M. Vernon; 1st Lieuts. William H. Barnes, Frank E. Grubbs, Thomas D. Smith, Jr., and William H. Wright; 2nd Lieuts. Robert T. Brunson, Merle H. Peterson, Bernard M. Schmitter, and Cleon V. Shock.

Artillery.—1st Lieuts. James S. Keel, Jr., and Carl V. Kling; 2nd Lieuts. Robert A. Hudson, Jules Lipcon, Benjamin S. Lowry, Harold E. Moore, Stuart H. Moyes, Frank Poulsen, and Vernon V. Vocelle.

Automotive.—Maj. Frank M. Browning; 1st Lieuts. Otis J. Adams, Waldo B. Berryman, John E. Hatcher, Joshua L. Holley, Jr., and John W. Krug; 2nd Lieuts. George Bullen, Paul E. Davit, and John J. Drislane.

Depot and Supply.—Maj. Amon T. Pagter; 1st Lieuts. Hugh H. Coleman, Charles H. Claypool, Jr., and Merrill L. Larson; 2nd Lieuts. Carl P. Blakely, William K. Maddox, John W. Potts, Jack A. Roll, Donald T. Rudgers, Russell A. Souchek, and George C. Jordan.

Small Arms.—1st Lieuts. Byrne C. Manson, and Frederick C. Thompkins; 2nd Lieut. Robert F. Hopper.

Regular Army.—Capts. Stanley J. Cherubin, Milton H. Clark, Napoleon R. Duell, Joshua A. Finkel, Merten K. Heimstead, George F. Leist, William R. Maxwell, Robert B. Partridge, Orville N. Stokes, and Thomas E. Wood; 1st Lieuts. Rolf O. Wulfsberg, Jack L. Grubb, Albert L. Robinette.

ORDNANCE CHANGES

SEVERAL changes in key personnel of the Ordnance Department have resulted in change of command among three of the larger establishments:

Brig. Gen. Edward M. Shinkle, formerly commanding officer of Picatinny Arsenal, retired from active service having attained the statutory age;

Brig. Gen. Rolland W. Case, formerly in command of the Watertown Arsenal, is now in command of the Aberdeen Proving Ground;

Brig. Gen. John B. Rose, formerly in command of the Aberdeen Proving Ground, is now chief of the Ammunition Division, Office of the Chief of Ordnance;

Col. John Mather, formerly assistant to the Commanding Officer of the Watertown Arsenal, is now in command of that establishment;

Col. William E. Larned, formerly assistant to the Commanding Officer, Picatinny Arsenal, is now in command of that establishment.

From the Record

DURING THE PAST YEAR, THE WAR DEPARTment has been working to increase the number of volunteers, or 3-year men, to meet the increased requirements for the present overseas garrisons such as Panama, Hawaii, and the new Atlantic bases; also to supply the large numbers required for Air Corps units, together with a sufficient percentage of long-service men to give stability to the Regular organizations in the United States, particularly the technical armored corps.

In addition, the Army has been endeavoring to provide the necessary numbers of volunteers to carry out the President's announced policy of relieving the Marines in Iceland and the elements of the British Army stationed there. The recruiting campaign to secure men for the Iceland command was initiated last August at Camp Custer among the units of the Fifth Division. We still have to meet the necessity for 10,000 men for this purpose.—*Gen. George C. Marshall, Chief of Staff, U. S. Army.*

IN THE PROCUREMENT OF MILITARY SUPPLIES it is necessary for the Army to enter into contracts which are of long duration. It is difficult to negotiate contracts which call for the payment of a fixed amount if the possibility of price fluctuations makes the prediction of future costs highly uncertain. In many cases we have felt that it was no more than fair to provide so-called escalator clauses to take account of changes in cost resulting from rising prices of labor and materials. But the only completely acceptable solution is the maintenance of a stable basis for cost anticipation.

It is my view that we will be unable to secure maximum military output from our economic system unless the Government and its contractors are able to plan without harassment by wild price movements. In this connection I should like to quote the remarks of Mr. Bernard Baruch before the War Policies Commission in 1931. He said: "As to the morale of industry at large in the World War, the uncertainty of the daily fluctuation of price and the inevitable rising trend on all sides was a matter for common commiseration. I am aware of no able and experienced business administrator who does not prefer operation under stable conditions to operation under price schedules in an unforeseeable state of flux."—*Robert P. Patterson, Under Secretary of War.*

MODERN WAR HAS DEVELOPED WHAT IS KNOWN to military men as the combat team. This team is made up of infantry, artillery, tank and airplane units, and many other arms and services, and functions with coördination. The combat group is one of the most effective developments in modern war. But to have combat teams in action at the front, we must have similar combat teams in the field of production. The coördination of fighting groups must be matched by the coördination of production teams in industry.

These combat teams of industry have been formed and are now operating. They have produced the machine guns made at this plant (High Standard Manufacturing Company, New Haven, Conn.). These teams of production are made up of the technicians of the Ordnance Department and of professional societies and industry, the managers that direct the work of private industry, and, not the least in importance, the workers who actually make these machine guns. This American combat team of production—the Army, industrial management, and labor—cannot be beaten.—*Brig. Gen. R. H. Somers, Assistant Chief, Industrial Service, Inspection, Office of the Chief of Ordnance; former editor,* ARMY ORDNANCE.

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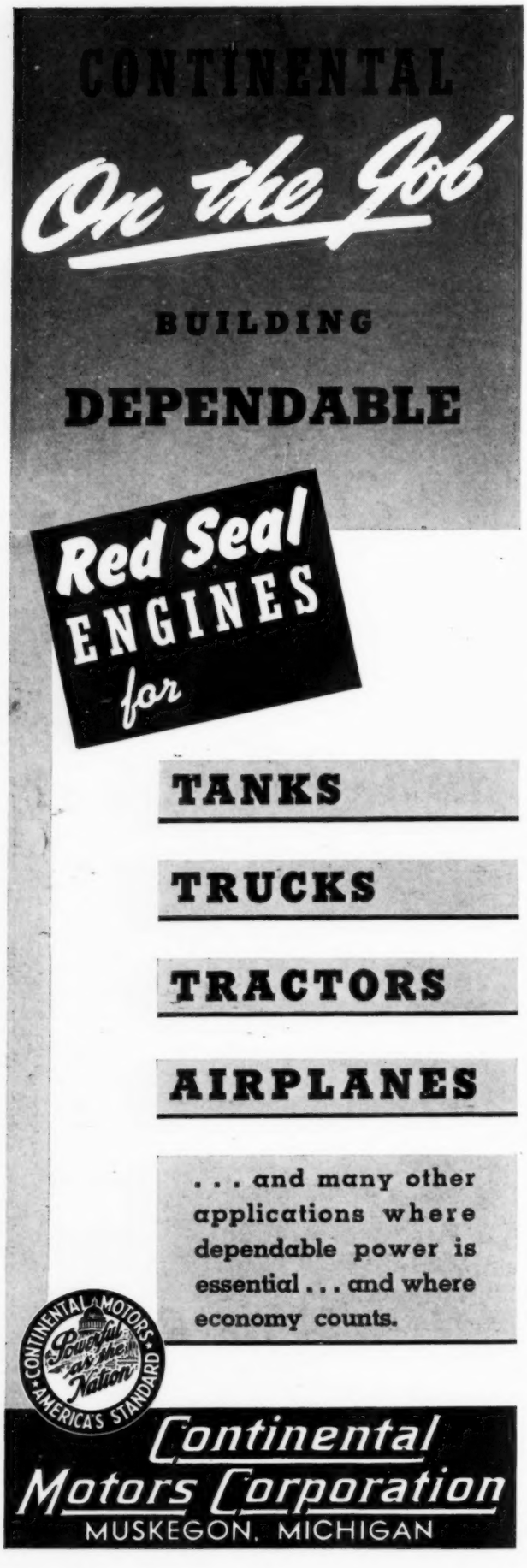

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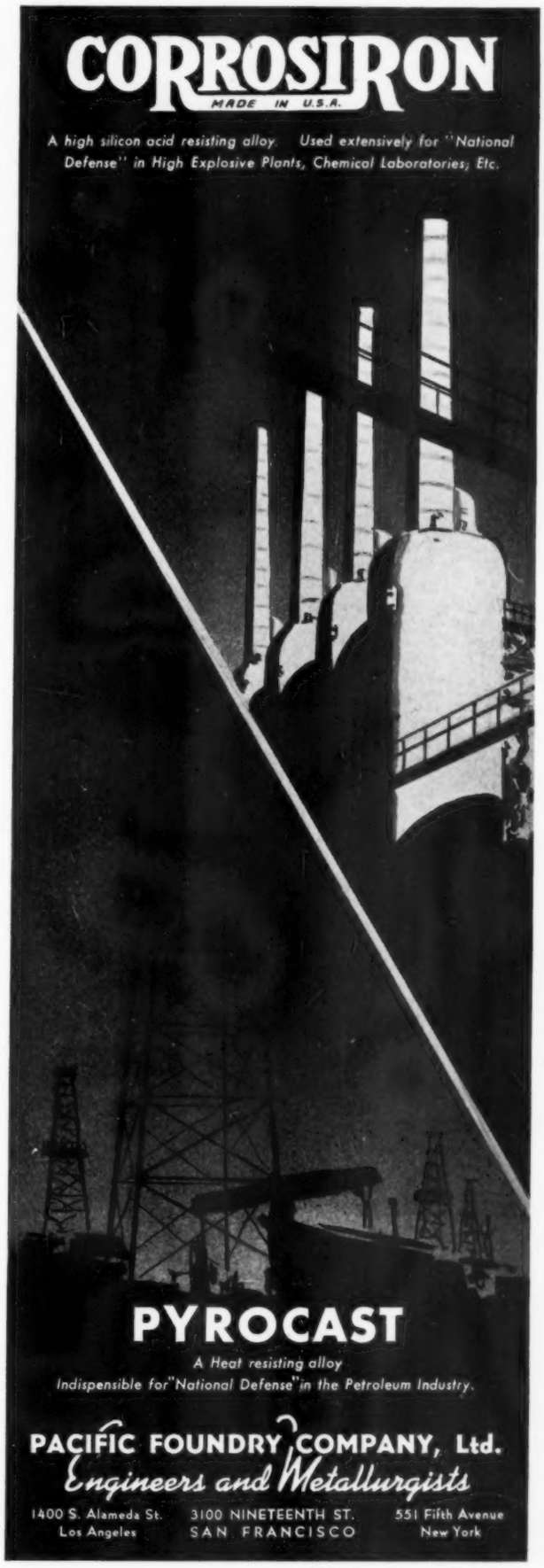
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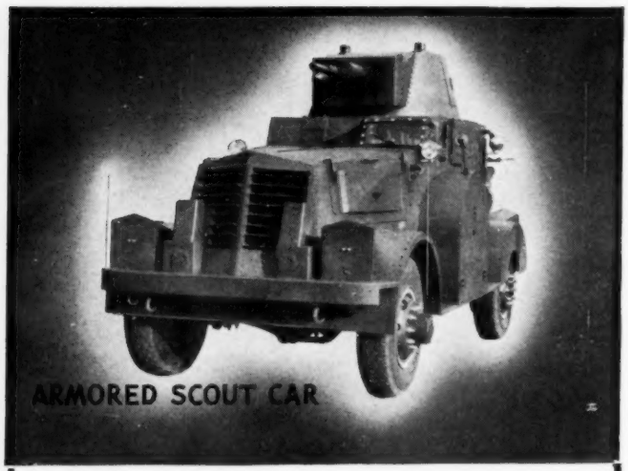

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Book Reviews

WHAT THE CITIZEN SHOULD KNOW ABOUT OUR ARMS AND WEAPONS. By Maj. James E. Hicks. New York: Norton & Company. $2.50.

AN officer of much experience in the Ordnance Reserve Corps and author of several serious works on American and European firearms, Major Hicks now has written a book of quite diverse mission. The present volume makes no pretension of being a reference work for the advanced student of the subject. Rather it is an instructive and entertaining digest for the layman and the novice. Cleverly combining simplicity and a sufficiency of basic information, he avoids either discouraging or disappointing the average reader.

Major Hicks has divided all weapons into ten classes or groups and devotes a chapter to each. In each case, a short summary of the weapon's historical development and tactical use adds very materially to the reader's interest and enlightenment. Throughout the book, a profusion of clear, explanatory drawings illustrate the text. And for each weapon is told, in a few words, our procurement difficulties of the past, our present status, and our future prospects. To be convinced that the book is literally up to the minute, one need but note that our Army's prospective change from the pistol to a light carbine is described in detail! The closing chapter is devoted to a short summary of the history of the Army Ordnance Department and to an excellent and quite comprehensive account of the Department today. An index adds much to the handiness and usefulness of the volume.

This is one of a series of texts written to inform our citizens as to the various branches of our national defense. A necessarily short interpretation of our ordnance, it seems well fitted to do its part. This reviewer hopes that Major Hick's stimulating style, aided by the inevitable appeal of weapons to the normal male, may impel many of the book's readers to further study of that fascinating trilogy: ordnance, military history, and the art of war.

F. W. FOSTER GLEASON.

BOMBS AND BOMBING: WHAT EVERY CIVILIAN SHOULD KNOW. By Willy Ley. New York: Modern Age Books. $1.25.

A MORE timely subject than that of this concise and competent treatise would be difficult to find. The entire topic of bombing from the air, and proper defense against the same, has been so well handled here that the value and importance of this little book is not to be measured by its 120 pages.

In opening his work, Mr. Ley considers the greatest dangers of air bombardment—ignorance, misinformation, and panic. The structure of blind terror, so assiduously built up over the past twenty years by large sections of our press and by scores of addle-pated romanticists of the Wellsian school, the author proceeds to demolish by a calm and factual analysis of every phase of the problem. Indeed, it is this demolition of "the fear of the unknown" which forms the true *raison d'être* of the work.

Succeeding chapters, amply illustrated by diagrammatic drawings, describe bombs of all types, how they are made, how they are used, and just what they will and will not do. Ley's evaluation of incendiary and gas bombs, and of sprayed poison (the so-called "dew of death"), is thorough and sound. The author's statement that, pound for pound, high explosive is approximately 500 times as effective as gas, while amazing, is backed by much corroborative evidence. Most interesting is his table of dates of the discovery of war gases. The two most effective known, mustard and phosgene, were found in 1855 and 1811!

The book then treats of the bombing plane and antiaircraft

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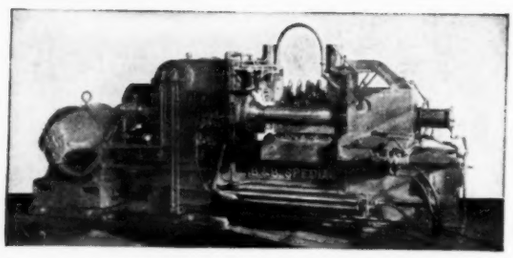

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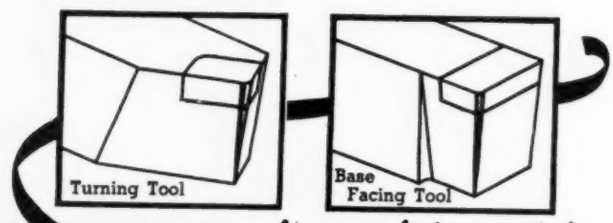

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defense. It concludes with a fine and detailed account of modern air-raid precaution measures. Most of Ley's contentions can be checked against the wholesale bombing with fire and high explosive during the past sixteen months. Ley is to be congratulated on a substantial contribution to the future defense of America. In this he differs admirably from many other prominent refugee scientists and writers who seem all too eager to chorus their assinine brayings upon any subject of which they know less than nothing!

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Books Received

The Destiny of Sea Power. By John Philips Cranwell. New York: W. W. Norton & Company. 262 pp. $2.75.

Language in Action. By S. I. Hayakawa. New York: Harcourt, Brace and Company. 239 pp.

Current Spanish. By José Martinez. New York: The Paulist Press. 218 pp.

Effects of the Defense Program on Prices, Wages and Profits. By Meyer Jacobstein and Harold G. Moulton. Washington: The Brookings Institution. 43 pp. $0.25.

What the Citizen Should Know about the Marines. By Capt. John H. Craige. New York: W. W. Norton & Company. 205 pp. $2.

Leadership—For American Army Leaders. By Maj. Edward Lyman Munson, Jr. Washington: The Infantry Journal. 96 pp. $1.

Manual of Mess Management. Harrisburg: The Military Service Publishing Company. 340 pp.

Preface to Preparedness—The Washington Disarmament Conference and Public Opinion. By C. Leonard Hoag, Ph.D. Washington: American Council on Public Affairs. 205 pp. Cloth edition, $3.

Song and Service Book—For Ship and Field. New York: A. S. Barnes & Company. 192 pp. $0.75.

The Soldier and the Law. By John A. McComsey and Morris O. Edwards. Harrisburg: The Military Service Publishing Company. 381 pp. $1.50.

Not All Warriors. By Capt. William H. Baumer, Jr. New York: Smith & Durrell. 304 pp. $2.50.

On Guard. By Joseph R. Sizoo, D.D. New York: The Macmillan Company. $1.

Great Soldiers. By H. A. De Weerd. New York: W. W. Norton & Company. $3.50.

Economic Consequences of the Second World War. By Lewis L. Lorwin. New York: Random House. $3.

Signposts of Experience. By Maj. Gen. William J. Snow. Washington, D. C.: United States Field Artillery Association. 312 pp. $2.75.

He's in the Army Now. By Capt. William H. Baumer, Jr. New York: Robert M. McBride & Company. 255 pp. $2.50.

Fighting Ships of the U.S.A. By Lieut. Victor F. Blakeslee. New York: Random House. 76 pp. $1.

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